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The Elba Iron Ore Loading Plant

Industrial Operations on the Historic Island

ONE of the most interesting ore loading plants is that installed for handling the rich and extensive deposits of iron ore on the island of Elba. The Societa Anonima di Miniere e di alti Forni "Elba" use this ore in their own blast furnaces and steel works at Portoferrajo and Follonica and the Societa Siderurgica di Savona also work Elba ores in their plants at Bagonli, near Naples, the same ores also being smelted in the Piombino works.

The main deposits are found on the precipitous east coast, in the mountains to the north of Rio Marina. The Pero mountains with Mount Calendozio's precipitous sides rising almost perpendicularly from the sea contain the important Rio Albano deposits which are worked in the Cape Pero, Calendozio, Albano Pistello, Puppaio, Grattarino, Grotta, Giuncaia, Tarambano and Imbuto mines.

The second ore producing hill, Gigo, near Oortello to the north of Calendozio reaches a height of about 1,160 feet and this deposit is worked by the two mines known as the Zuccoletto and Rosseto. The extensive deposit, near Rio on the same coast, is estimated at 11,000,000 tons and the Sanguinacci, Polveriera, Pozzi Fondi, Falcacci and Fabbriche mines are also located here.

Continued on page 344.

THE LOADING PIER ON THE ISLAND OF ELBA, SEEN FROM THE HILL

The Present Status of the Diesel Engine in Europe—III*

And a Few Reminiscences of the Pioneer Work in America

By Dr. Rudolph Diesel

Concluded from Supplement No. 1899, page 331

MARINE ENGINES.

THE first marine Diesel engine of 20 horse-power was constructed in 1902 to 1903 in France, for use on a canal boat, by the French engineers Adrien Bochet and Frederic Dyckhoff, in conjunction with myself.

This engine had two pistons working in opposite directions in one cylinder. The engine worked on a four-stroke cycle. Others were also built in various sizes up to several hundred of horse-power for some French submarines by Sautter, Harle & Co., Paris.

This type of engine is of no further practical interest to-day, but it has at least the historical interest of being the first Diesel engine to be used on a boat. Since the date named, the evolution of the Diesel marine engine has steadily continued, chiefly on the demand of the French submarines and Russian river boats. I have already mentioned that later on the high speed, four-stroke cycle engines, built for electric power stations, were made even lighter than before, and used for French submarines and for Russian river vessels. These engines were not originally reversible; on the contrary, they were used to generate electricity by means of which the propellers were driven indirectly for maneuvering. The first reversing two-stroke cycle Diesel engine was built in 1905 by Messrs. Sulzer Brothers at Winterthur. At that time engineers were not quite clear as to the importance and value of the two-stroke cycle principle, and many firms went on trying for years to make the four-stroke cycle engine reversible. The first engine of this kind was built by Messrs. Nobel Brothers at St. Petersburg in the year 1908. It was a 120 horse-power, three-cylinder engine and was fitted to a Russian submarine. Great mechanical complications were at first caused by the reversing of the four-stroke cycle engine.

In many factories reversible four-stroke cycle marine engines are still built, but, on the whole, engineers are, for navigation purposes, inclined to abandon the four-stroke cycle engine entirely and to replace it by the two-stroke cycle engine.

A small four-cylinder engine of 30 horse-power and 600 revolutions per minute was built for experimental purposes in the year 1909 as an automobile engine for heavy loads. The cam shaft was mounted on the cylinder cover. It represented the first attempt to construct the Diesel engine as an automobile engine for traction wagons, and no doubt in future years these experiments will lead to satisfactory results.

For larger sizes of ship engines no standard type can be laid down as yet. Each ship and each engine must be treated individually. Although several of the engines of Diesel liners are at present four-stroke engines, it appears unquestioned that the large ship engines will develop on a two-stroke type with cross-heads and with exactly the number of revolutions wanted by the propeller, and there is a tendency to make these engines as nearly as possible to resemble steam engines, even in those points where it would not be necessary, because the marine people adopt new things very much more easily when they look like what they are accustomed to.

It is generally known that very important experimental work is being done in different places for the purpose of developing high power marine engines with cylinder units reaching 1,000 to 2,000 horse-power and more. Some manufacturers solve this problem with double acting, others with single acting cylinders, but all on the two-stroke cycle. The M. A. N. is experimenting on a 6,000 horse-power two-stroke double acting engine with three cylinders of 2,000 horse-power each. Messrs. Sulzer Brothers are just erecting a single cylinder of 2,000 horse-power single acting, based on a construction which permits an entirely free expansion of the cylinder under the action of the varying temperatures. Krupps Germania Yards have a 2,000 horse-power cylinder double acting on the testing stand. Vickers Sons & Maxim are experimenting on a large scale with the double acting, two-stroke cycle type.

If, as seems probable, tests now under way give satisfactory results, the era of very large Diesel engines has begun. From motives of prudence, the various navies which are now fitting some warships with Diesel engines started with one Diesel only out of the two or three engines on board; the Diesel works alone when the ship is cruising, but for high speed, steam is used as an auxiliary. It is evident that large warships will not be fitted solely with Diesel engines until practical tests on the high seas have proved them to be completely successful.

DIESEL SHIPS.

I believe it would be of interest to you to get from me a complete list of Diesel propelled ships, but as such would be too long, and the reading of it would prove a little tedious, I will give you a summary of Diesel engine vessels built or under course of construction. The total aggregate of these vessels is 365, and an analysis shows the following distribution:

Oil tank vessels	about 30
Tugs	" 40
Motor sailing vessels	" 10
Merchant vessels, freight, passenger and combined	" 50-60
Fishing boats	" 15
Submarines (among them 17 U. S. Navy submarines)	" 140
Smaller warships, small cruisers, gunboats, mine laying boats, and the like	" 40
Small marine craft	" 20
Miscellaneous	" 20

To-day, the navies of the world have adopted almost exclusively the Diesel engine as the motive power for submarines, after I had done the pioneer work in that direction in my offices in Munich in connection with several engineers of the French Navy.

Mr. Davidson in England has calculated as follows the influence of replacing the steam engine by a Diesel engine on the destroyer "Paul Jones" of 400 tons displacement, 8,000 indicated horse-power engines:

	Steam.	Oil.
Weight of engines	449,000 pounds	317,000 pounds
Weight per brake horse-power	64 "	44 "
Radius of action at 10 knots and 180 tons fuel	1,700 knots	10,000 knots
Radius of action at 28 knots and 180 tons fuel	630 "	2,950 "
Fuel per brake horse-power hour, with 20 knots	2.34 pounds	0.5 pound
Engineers and stokers	54	21
Fuel consumption in 1 year (20,000 marine miles)	2,100 tons	360 tons
Cost of fuel	$3,840	$924
Cost of engine crew labor	4,500	1,920
Cost of repairs	2,000	400

LOCOMOTIVE ENGINES.

Of the Diesel locomotive nothing has been published yet, and it is a special pleasure to me to give my first description of the first Diesel locomotive ever made in this country of mighty oil wells and gigantic railways. From the early days of my invention I was of the opinion that the special features of the Diesel engine would be of even greater importance for transport purposes than for stationary work and for that reason I devoted myself extensively to the development of the engine as motive power for transportation mediums. I have already mentioned that I made the first small ship engine in 1902 and that since that time the Diesel marine engine has been developed without interruption. I further mentioned that I made the first automobile engine for trucks in the year 1899, and that I looked forward to the development of this branch within a few years. Finally, I have to say that I have worked for five years, together with Sulzer Brothers, at Winterthur, and Mr. Adolph Klose of Berlin on the construction of a Diesel locomotive, and that the first express train locomotive of 1,000 to 1,200 horse-power was finished a few weeks ago, and is now on the testing bed in the Winterthur shops. Five years is a very long time, and to explain why the work has taken so long, I must mention that the thermo locomotive is the most difficult problem of construction that can be taken up in the way of modern engine building, not only on account of the difficulties in starting and maneuvering with this special kind of motor, but also on account of the excessive limitation in space and weight. Compared with this, the development of the reversing marine motor has been relatively simple. Slide 60 shows the design of this locomotive, the car of which was made in the renowned locomotive works of A. Borsig at Berlin. It is 16.6 meters long over the buffers and has two buggies of two axles each, and two driving wheels. The latter are not directly coupled with the engine but indirectly with the blind axle which is in the meantime the crank shaft of the Diesel engine.

The Diesel engine is an ordinary two-stroke cycle engine with four cylinders coupled in pairs under an angle of 90 degrees, which drives the blind axle whose cranks form an angle of 180 degrees. This disposition gives complete balancing of the moving masses, the first and most important condition when putting such engines on a movable platform. Between the working cylinders are placed two scavenging pumps driven by levers from the connecting rod. Beyond the engine in the roof of the car is placed the silencer. On the right of the main engine stands an auxiliary engine. This latter consists of two vertical two-stroke cycle cylinders coupled to horizontal air pumps driven by these cylinders. A cooler is provided for the air compressed by these pumps. These air pumps serve, according to a special and patented process, to increase the power of the main engine when starting, maneuvering and going up hill in such a way that auxiliary compressed air and auxiliary oil fuel are conducted into the main cylinders, by which means the diagram is enlarged, which makes the engine as elastic as a steam engine. For the current running of the locomotive the main cylinders work like ordinary Diesel engines without the help of the auxiliary. To the right of the main engine is placed a battery of air bottles which help the action of the auxiliary engine and which can be refilled by the auxiliary engine at times when the latter is not used. Two pumps provide for the water circulation in the cylinder jackets.

The whole plant is contained in a closed engine room which makes the locomotive look from the exterior like one of your steel cars.

The engineer can operate equally well at either end of the locomotive, as the engine is arranged for running in both directions. He has a direct view over the track. Doors and platform lead from the engine to the train.

The total weight in service of the locomotive is 85 tons.

I cannot predict whether this attempt at an entire revolution in the working of railways will be successful at the first attempt, or whether it must be repeated, but one thing is certain to me: The Diesel locomotive will come, sooner or later, according to the perseverance with which the problem is followed.

CONCLUSION.

Before concluding my lecture I should like to touch a very important question which has been put to me by the Secretary of the United States Navy, to whom I paid my first visit when coming to this country, and which has been repeated to me nearly every day since I left the pier at Hoboken.

Why are we in America so far behind Europe in the development of this new prime mover, which in fact is no longer new to-day?

To answer this question I must emphatically state that the Diesel engines built in this country, after having passed the necessary manufacturing apprenticeship more than ten years ago, have been and are quite as good as our European machines. So the question is not a technical one, but merely a commercial one or even more one of the general economical conditions in this country. I do not know the United States sufficiently to judge these conditions on my own behalf, but I have tried to find out in my conversations with many of your prominent engineers, and the following is what I could learn:

First. Coal is much cheaper than in Europe, and therefore, people are more wasteful with it; while the leading idea in Europe is always the economy in operating cost, the leading idea in America is economy in first cost. The word efficiency which is the base of every contract with us seems to be unknown to a vast proportion in this country, of course, not to engineers, but to business men and to buyers of engines.

Second. In the same order of ideas, your steam engines are much cheaper than ours. But the Diesel engine is not and will not be a cheap engine; it aims to be the best engine and must be constructed of the highest class material, with the best tools and by the most skilled workmen; this makes it difficult for it to compete when such ideas as mentioned above are prevailing.

The people here are accustomed to a very low price

* Abridged report of a paper read before the American Society of Mechanical Engineers.

of engines, taken per pound, and the price of Diesels per pound seems to them exorbitant; several people have said that they would never buy an engine at that high price per pound, even with a guarantee that the whole plant would earn its cost by the savings of a few years only.

Third. Another general reason seems to be in very many cases the lack of capital of the prospective purchaser, and also in many cases the higher rate of capital interest prevailing in the American money markets.

Fourth. A further reason is this: That in the last few decades the general business profits have been so big that people did not care for the most economical methods of production and for the strictest economy in the fuel bill as well as other expenses, the ruling object having been to manufacture quickly and in quantities without regard to the cost. You had not, as we in Europe, to compete with the industrial countries of the world.

I have been told by American engineers that what has happened to the Diesel engine has also exactly happened to the large gas engine, especially with blast furnace gases, and also with the steam turbine, both of which have been taken up in this country long after their development in Europe.

The same has also happened with the by-products of coke ovens. Even to-day, the wasteful beehive oven is in use, while in Europe the industry of the valuable by-products earn hundreds of millions every year, and have had the tendency to keep the prices of the natural liquid fuels on a lower and proper level.

All the conditions I have alluded to seem to be changing rapidly now; this terribly wasteful performance begins to be recognized, competition has become more keen, and a conservation of natural resources is striven for more than ever before. If this is true, the high class engines with the highest efficiency will begin on this side of the ocean to have the same importance as abroad. In conclusion, I express the hope that I have succeeded in giving you a true and clear picture of the development of the Diesel engine in our old Europe, with a few reminiscences of the pioneer work in America. And I must call to your mind the fact that nowhere in the world are the possibilities for this prime mover as great as in this country.

The Strength of Large Ships

Is Increasing Size Accompanied by Increasing Frailty?

A letter addressed by Reginald Ryves to the Editor of "The Engineer," is reproduced here in full in view of its seasonable interest in connection as to the recent Titantic disaster.—Ed.

"THE failure of the biggest ship in the world to keep afloat for more than a few hours after running into an iceberg raises the important question, 'Are the biggest ships the safest?' It will be asked whether there is not some limiting size beyond which the safety of any type diminishes as the dimensions are increased. The issue has been obscured by the fact that so far increases in the dimensions of ocean liners have been accompanied by safeguards which had not been so fully made use of in the older ships. These safeguards can, however, be applied as easily to ships of 15,000, 10,000 or even 6,000 tons displacement, as to the giant liners, so that they need not be considered in a comparison between ships of different sizes. We have, then, only to consider the effect of size in itself upon strength and upon safety. A ship is a framed structure, and is subject to the natural laws which govern the design and determine the strength of framed structures. Now, as the size of a framed structure increases, the spreading apart of the different members adds to the strength, up to some point, and then, if the character of the structure remains the same, increase in size reduces the strength. That is, the strength is reduced unless the material be collected together with larger and relatively fewer members. There is sometimes the alternative of using much more material, proportionately, but in land structures we are usually limited in this respect by cost, or by the necessity for keeping within some limit of pressure upon the ground or upon the structures supporting the framework. In the case of a ship, even if we were not limited as to cost, we could not maintain strength by liberality in the quantity of material, because the ship has to float. More than this, the naval architect has to satisfy very exacting requirements which interfere radically with the disposition of his materials. As we increase the size of a ship we cannot get rid of the skin, or hull, although that becomes, relatively, of less and less use for strength as size increases. It is as though the designer of the Eiffel Tower had been obliged to carry over the whole surface of the structure a network of steel bracing similar to that which we have in a railway signal post. The increase in the dimensions of a solid iron post to a hollow one gives a gain in strength. Beyond that, we have a further gain if we condense the shell into four posts connected by the little bracings of the ordinary economical design. If, however, we have to support a weight and wind loads many times as great, the individual members of the structure become much larger. This principle is not and cannot be fully carried out in a very large vessel, in which such a main construction, together with the detailed construction necessary for local stiffening of the hull and strength in the many decks, would involve too much deadweight. Moreover, the proper positions for the struts and ties necessary to give strength proportionate to that of a smaller ship—that is, equal in result—cannot be utilized on account of the size and positions of spaces, such as the engine-room and the large saloons. In a small vessel the difficulty is much less, because the keel, sides and main deck are all closer together. With other structures it is recognized that the bigger the structure is, the larger is the proportion of its material needed to maintain itself and the less is the proportion available for service. The Forth Bridge was not expected to carry a width and depth of traffic accommodation greater than that afforded by bridges of half its span. The analogy does not hold as regards the design of a ship as a thing to float, because the support is continuous, but it does hold as regards the design of a ship as a thing capable of ramming an iceberg or lying across a reef with several feet reduction of its draught.

"As regards collisions with other vessels, there is, of course, this in favor of a very big ship, that the amount of damage done is likely to be smaller in proportion to her size than in the case of a smaller vessel, but there are many practical reasons why the case of a large ship with many persons on board is worse than that of a smaller ship if she be damaged so much that she can only remain afloat for a short time. The chances of a large ship being rammed are far greater than those run by a smaller vessel. When a ship looms up suddenly out of a fog, crossing the bows of another vessel, it may be easy to avoid her, let us say, if she is 300 feet long. If she is 500 feet long there is 100 feet length to be cleared at one end or the other by the skill and alertness of the captains. If, however, she is 800 feet long the length to be cleared is 250 feet. The "Titanic" in such a case would be more than twice as difficult to clear as the "Saxonia." As regards running into an iceberg or a reef, the bigger the ship the greater is the distance required to reduce her speed by a given amount, so that if a reef be sighted at the same distance ahead in each case, the ships having the same speed, the larger ship will be traveling the faster when she strikes.

"In comparing the strengths of ships of different sizes to resist the effects of running into a reef or ramming an iceberg, it is idle to say that as the fore part of the ship will necessarily crumple up in such a case the comparison is of no importance. The safety of the passengers and crew depends upon the length of time that the ship can remain afloat. That period will depend upon the relative amount of damage. The relative amount of damage will depend upon the strength of the fore part of the ship in proportion to the energy to be absorbed. Suppose that the ripping up of 220 feet of the "Titanic's" bottom, tearing open the water-tight spaces, will leave her with an hour before sinking, and suppose that similar damage to the "Saxonia"—which is 580 feet long—along 140 feet of her length would have the same result. Does any naval architect maintain that at the same speed the greater depth and beam of the "Titanic" would involve so much greater strength that her 45,000 tons would be stopped by 220 feet length of such damage more easily than would the 14,300 tons of the "Saxonia" be stopped by 140 feet length of similar damage to her bottom? On the contrary, the damage would be relatively far greater with the larger ship. Again, in a collision with an iceberg the whole energy of the blow is absorbed by splintering ice and by the crumpling up of the forepart of the ship, and the stronger the ship the less is the proportion of damage done to her and the greater the share borne by the ice. If the speed is considerable, which we are assuming is the case, the safety of the ship depends absolutely on the capacity of the fore part to resist crushing of the bows and crippling of the part abaft the bows, and the mechanism intended to actuate the doors in the bulkheads. The strength needed is strut strength. If we were to regard the fore part as one strut and assume that its strength varies approximately as the squares of its cross dimension and inversely as the square of its length, a ship like the "Saxonia," with beam and depth about two-thirds those of the "Titanic," would have a fore part four-ninths as strong, to resist a blow only one-third as great on a strut, two-thirds the length. Taking, for simplicity, a ship just two-thirds the length of the "Titanic," the advantage in her favor is:

$$\frac{2}{3} \times \frac{3}{1} \times \frac{4}{9} \times \frac{9}{4} = 2$$

The first factor $\frac{2}{3}$ represents the shorter length to be crippled to give the same proportion of length crippled; the second factor $\frac{3}{1}$ represents the advantage of the smaller mass, 15,000 tons, say, against 45,000 tons; the third factor $\frac{4}{9}$ is the square of the least—or weakest—cross dimension; and the last factor, $\frac{9}{4}$, is the square of the proportionate lengths of the fore part regarded as a strut.

"It may, however, be contended, and with reason, that we cannot regard the fore part of the ship as one strut. Let us therefore consider it as a cellular mass which will hold together while it is being crushed progressively from the bows backward. What is the relative length crushed or partly crushed in each case? If we make a calculation on the assumption that the cellular mass is equally strong in each case, that is having the same amount of material per cubic foot equally well arranged, we have this result:

"The actual—not proportionate—length crushed in each case

$$\frac{\text{"Saxonia"}}{\text{"Titanic"}} \quad \frac{1}{3} \times \frac{3}{2} \times \frac{3}{2} = \frac{3}{4}$$

The proportionate lengths crippled—

$$3 \times 3 \text{ and } 4 \times 2 \text{ or } 9 \text{ to } 8,$$

i. e., the effect on the "Saxonia" would be ⅛ more severe.

"Everything depends, then, upon whether the assumption of equal cell strength is true. Any advantage possessed by the larger ship in the form of long members (lengthwise) of great strength would be lost by the adverse effect of the greater length of such members. The question then is, can ships of 45,000 tons be so built, or are they so built, that the cells are as strong and as small as those of a 15,000-ton ship? Or, if they are larger, are they stronger in the proportion of the squares of relative length? Including in the term 'cell' all structural spaces, and the lengths of the plating between frames, let us assume that the lengths of these cells are in the proportion of 3 to 2, the same as the whole lengths.

"We then get the expression for the measures of the actual lengths crushed—

$$\frac{\text{"Saxonia"}}{\text{"Titanic"}} \quad \frac{1}{3} \times \frac{3}{2} \times \frac{3}{2} \times \left(\frac{2}{3}\right)^2 = \frac{1}{3}$$

and the proportionate lengths become:

$$1 \times 3 \text{ and } 3 \times 2 \text{ or } 1 \text{ to } 2.$$

"We get the same result by taking the 9 to 8 already found and applying the strut-length factor—that is, 9 to 8 becomes 9×4 to 8×9, or 1 to 2.

"This would make the smaller ship twice as strong as the larger in the case of ramming an iceberg. As regards running on to a reef, the comparison would be far more favorable to the smaller ship because most of the extra size of cross-section of the big ship would be ineffective in preventing the damage. Can the advocates of very big ships show that the 'cells' are no bigger than those of smaller ships? All the dimensions of the cells count, but the lengthwise dimension matters most.

"Similar calculations, but far more favorable to the smaller ships, could be made for the case of a vessel lying across a sand ridge or a reef on a falling tide, or with her bows heaved up on to an ice ledge. If struck full in the beam by another ship the large vessel offers a stiffer resistance than a small one; the crumpling of the bows of the striking ship allows an appreciable interval in which she would begin to move a small vessel, the energy so absorbed reducing the amount to be accounted for.

"The matter of speed is, of course, all important. Probably the directors of steamship companies have not yet fully grasped the fact that a ship traveling at 21¼ knots will, in full collision, do twice as much damage as a ship traveling at 15 knots. If the damage done be doubled, the time that the ship will remain afloat is likely to be reduced by more than half, and a further practical consideration is that with half the time the peril is much more than doubled.

"The profound ignorance that exists on the subject of applied mechanics is shown by remarks such as the following, which is from a penny daily paper: 'When the tonnage and the speed are taken together we arrive at a total weight of impact so tremendous as to take us beyond all region of experience and even to make speculation uncertain.' It is remarkable that the writer should have selected the one thing that can be calculated with certainty, absolute as well as comparative."

American Aeronautic Motors

Description of a New Rotary Motor and a Six-cylinder Engine with Concentric Valves

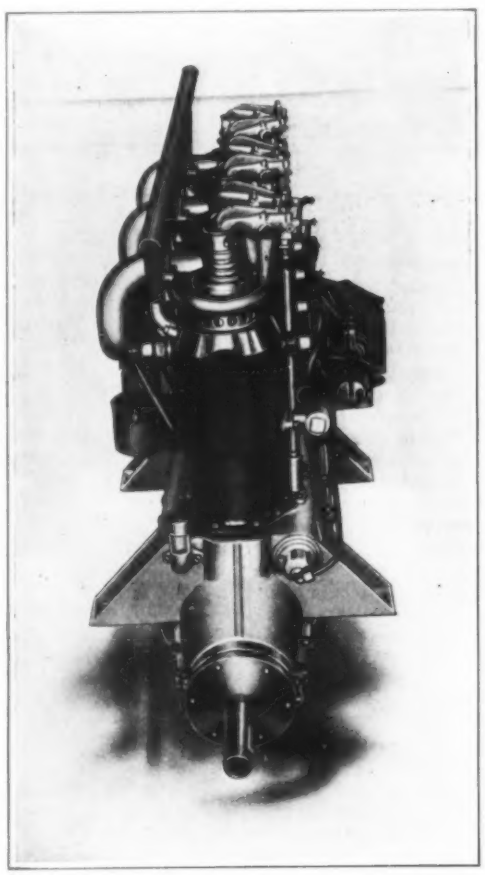
By Stanley Yale Beach

PROBABLY the most interesting revolving-cylinder motor exhibited at the recent Aero Show, as described in the last issue of the SCIENTIFIC AMERICAN, was the 7-cylinder, 50 horse-power engine, designed and constructed by Mr. Willard Irving Twombly.

For a weight of 112 pounds complete with carbureter, magneto, and wiring, this motor develops 50 horse-power at 1,000 revolutions per minute. It has a bore of 4 inches and a stroke of 4¼ inches, and it is a marvelously light motor for the horse-power developed,

Like the Gyro motor, which was described recently in these columns, the Twombly motor has a mechanically-operated inlet valve in the head of each cylinder. Its main feature, however, is the doing away with the half-speed cam shaft used on practically all four-cycle motors, and the operation of the valves direct by means of small sliding shoes on the ends of the valve push rods. These shoes, which are made of bronze, travel in two annular cam grooves placed around the end of the stationary crankshaft, as shown in our illustration. Both these grooves are eccentric, the outer one more so than the inner, and they connect together at a given point, as can be seen by looking at the photograph. When the valves are not in operation, the shoes travel around in the inner slots, while when the exhaust valves are to be opened, the shoes are switched from the inner to the outer slot, which slot is made sufficiently eccentric to the shaft to open the valve and close it in one revolution of the motor. In our illustration one shoe, S′, is shown just after switching from the inner groove to the outer, while the other, S, is shown being switched from the outer groove to the inner. Two cams on the two grooves effect this switching of the shoes. By this means the valves are opened and closed positively without the use of springs, and there are no gears or regular cams such as are used in the ordinary four-cycle motor. The inlet valves in the heads of the pistons are operated in the same manner from a double groove placed about the crank pin. The push rods which operate these valves lie in the connecting rods (C in the sectioned cylinder) and are connected to shoes that slide in the groove, in the same manner as those shown in the illustration. The cylinders are provided with auxiliary exhaust ports protected by an expanding band of aluminium. This expands and allows the exhaust to escape through the ports, but immediately contracts afterward and keeps the dust and dirt from getting into the cylinders.

In order to obtain such extremely light weight, the Twombly motor is made of excellent material, and displays very fine workmanship. The crank case, which is in two halves, is made of magnalium, and is thoroughly machined both inside and out. Clamped to it by means of four dogs each, are seven radially disposed cylinders of special nickel steel. These cylinders are machined from a special tube of steel which is drawn from a billet weighing 56 pounds. This weight is reduced to 4 1/4 pounds in the finished cylinder. The cylinder is but 1/16 of an inch thick at the base, and it tapers to 3/32 at the head. It is provided with 19 cooling flanges having a thickness of 3/64 of an inch and an outside diameter at the widest point of 5 1/4 inches. These flanges taper to nothing at about 2/3 of the way down the cylinder wall and they also taper toward the top of the cylinder. Half an inch above the bottom of the cylinder is the clamping flange which is about 3/8 of an inch thick. The end of the cylinder fits into the hole in the crank case, while the cylinder is clamped in place by four bolts passing through the crank case and by four small dogs that bear upon the upper surface of the bottom flange. The stationary crankshaft is made of vanadium steel. It is hollow, and projects out to the rear of the motor from two to two-and-a-half feet.



End View of Kirkham 6-cylinder Aviation Motor.

The photograph shows the propeller end of the motor. Note the concentric valves in the cylinder head.

The carbureter is mounted on the rear end of this hollow crankshaft. The gas enters the crank case through the hollow shaft, and makes its way through the inlet valve at the head of the piston into the cylinder. As the mechanically operated valves in the heads of the pistons are all kept open a full half revolution, much better charges of gas are introduced into the cylinders than can be had with the ordinary automatic inlet valve such as is used on the Gnome motor. The oiling of the motor is done automatically by means of centrifugal force. On the rear side of the crank case—the side opposite to that shown in the illustration—there is located an annular reservoir into which the oil is fed from the oil tank by gravity. Pipes from this reservoir run up to each cylinder and connect with it at the point where the auxiliary exhaust ring is placed. A needle valve is located in each pipe at the point where it enters the cylinder, and by adjusting this, the flow of oil is regulated to a nicety. Oil is introduced into the crankshaft for the lubrication of the crank pins and wrist pins in the pistons. Thus it will be seen that the motor is thoroughly oiled by means of gravity and centrifugal force, instead of by using a mechanical lubricator and feeding the oil into the crank case through the crankshaft, as is done with the Gnome and other revolving-cylinder motors. Ball check valves are located in each pipe to the cylinders in order to keep the oil from running out when the motor is at rest.

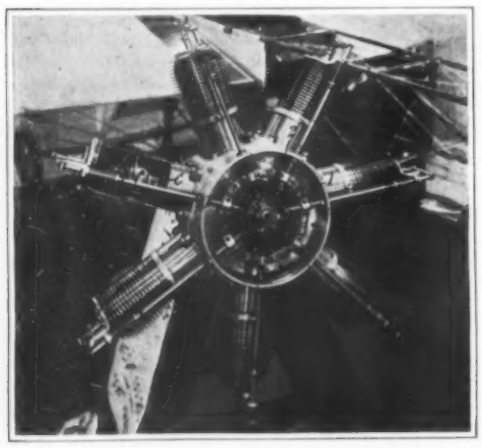
The method of throttling this engine is novel. The throttling is accomplished by oscillating the intake cam on the crank pin. This keeps the intake valves in the heads of the pistons open on the compression stroke for a predetermined portion of this stroke, and allows part of the charge to be forced back into the crank case. In this way the compression is varied from practically nothing to a maximum of 45 pounds per square inch. A magneto for a single-cylinder engine, geared 1 3/4 to 1 from the revolving cylinders, provides sufficient current to ignite the charges in all seven of them. The single gear which drives this magneto is the only gear in the entire engine.

The revolving cylinders are mounted upon radial ball bearings, and when the compression is relieved, these cylinders can be spun easily like a fly wheel. The motor can therefore be started when in flight by relieving the compression and allowing the propeller to turn it over rapidly. The compression and spark are then thrown on and the motor will immediately start to run.

During the past year Mr. Chas. B. Kirkham has brought out a six-cylinder motor which has proved itself to be reliable and a first-class motor in every respect. In designing his latest motor, Mr. Kirkham has followed the practice of the Panhard Company in France, in that he is using concentric valves in the heads of the cylinders. Such valves have been found to give excellent satisfaction in the R. E. P. aviation motor and also in the Panhard aviation and automobile engines. Our illustration shows the end view of one of these six-cylinder motors in which an excellent idea of the valves in the head is obtained. The exhaust takes place through the ring of holes seen near the top of the cylinder, while the inlet gas enters through the annular pipe seen around the top of the cylinder just above the holes. There are two rocker arms and two push rods to each cylinder. The magneto is seen on the right hand side and the carbureter on the left hand side of the motor. The cylinders are all in one piece with the water jackets cast integral. The jackets are flat on opposite sides to allow the placing of the cylinders closer together. The cylinder walls are but 3/16 of an inch thick and the jackets 3/64. The bore of the cylinder is 4 5/16 inches, while the stroke of the pistons is 5 1/8 inches. The brake horse-power developed at 1,680 revolutions per minute (which is the recommended speed) is 76.3 horse-power. Built into the end of the crank case is a special reduction gear with a shaft for the propeller. The speed of the crankshaft is reduced in the ratio of seven to four. This arrangement makes it possible to use a large diameter, high-pitch propeller, and at the same time run the engine at its most efficient speed. The propeller used is 8 1/2 feet in diameter, and has a pitch of 7 1/2 feet. It develops a thrust of about 500 pounds. The weight of this motor complete as shown is 260 pounds, which makes the weight per brake horse-power but 3.4 pounds. The gasoline consumption per hour is 45 pounds, and that of the oil, 4 pounds. With everything included, the weight of the power plant, fuel, etc., for a five-hour flight amounts to 585 pounds.

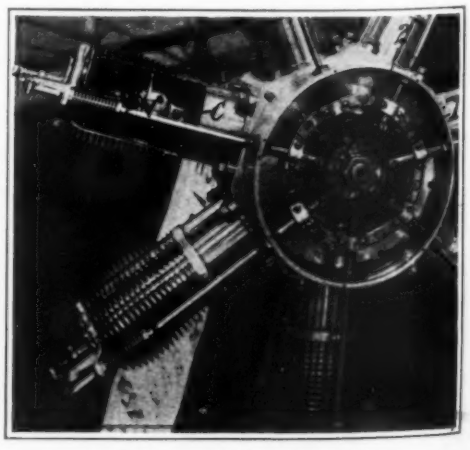
Mr. Kirkham also manufactures a four-cylinder motor of the same bore and stroke. This motor develops 38.3 horse-power at 1,300 revolutions per minute, for a weight complete as above of 185 pounds. This makes the weight per horse-power 4.8 pounds. The propeller used with this motor is mounted direct on the crankshaft. It is 6 feet 8 inches in diameter by a 4 1/2-foot pitch and gives a thrust of 280 to 300 pounds at 1,300 revolutions per minute. The weight of the power plant and all accessories for a five-hour run is 356 pounds, which is light indeed for the development of nearly 40 horse-power for this period of time.

Priming Coat for Gilding Frames.—Rub down white lead with linseed oil and mix it with sufficient oil of turpentine to make the mixture thinly fluid. The frames must be coated ten to twelve times and rubbed down. Varnish with (*a*) 4 parts shellac, 4 parts sandarac, 1 part mastic, 30 parts spirits of wine; or with (*b*) 8 parts shellac, 2 parts sandarac, 1 part Venice turpentine, 50 parts spirits of wine. After drying, polish with tripoli and gild.



Propeller Side of Twombly Motor.

One cylinder is sectioned showing piston *V* with inlet valve open in the head. The peculiar method of operating the valves is also shown.



Detail View of Valve Mechanism.

1 and 2 are outer and inner cam grooves; *S* and *S*′ the sliding shoes; *C* the wrist pin and connecting rod; and *V* the open inlet valve in piston head.

The Effect of Frost on Plants

Actual Freezing of the Tissues Does Not Necessarily Occur

By Our Berlin Correspondent

IT is well known that life is only possible within certain limits of temperature. While most succulent plants die when the temperature reaches 45 to 49 deg. Cent., some bacteria occurring in hay and inorganic refuse show a preference for temperatures fatal to other plants, and develop, multiply and are active between 60 and 70 deg. Cent. Certain algæ living in hot springs are said to stand temperatures of 57, 70, 85 and even 93 deg. Cent., though no reliable data seem to be available for temperatures above 50 deg. Cent., at which certain calcareous algæ have been found to live in the hot springs of Karlsbad and the Gedeh Vulcans in Java. Again, the dried seeds of many plants, as well as mosses and lichens, spores and bacteria, can withstand for one or more hours a gradual heating to 80, 100 and (for short periods) even 120 deg. Cent., without losing their vitality. In fact, the vitality of each plant thus has an upper as well as a lower limit of temperature.

However, the lower limit obviously is of far more immediate practical concern. In order to be nipped by the cold, some plants must be actually frozen, and conversely, frozen plants are not always killed by the frost. Some plants are in fact known to die at temperatures slightly above 0 deg. Cent., where no freezing can of course occur. Tobacco, pumpkin, bean and other plants wither on being exposed in flower-pots to temperatures of about 4 to 2 deg. Cent. If the temperature be raised to 18 deg. Cent., while maintaining the low surrounding temperature, the leaves of these plants will swell again and resume their previous vigor. In fact, at a few degrees above 0, their roots lose the faculty of absorbing sufficient water, whereas the leaves by vaporization continue to give off water in relative abundance. While the leaves thus perspire strongly, the roots only absorb little water, so that the plant begins drying up. If these plants be, however, surrounded with water globes preventing perspiration, they will resist a low temperature, and not be withered. Other plants apart from perspiration effects are frozen immediately above 0 degree, the metabolism of their living matter undergoing some serious disturbance.

However, the freezing proper of plants obviously is of much greater importance than these isolated phenomena. Some plants such as daisies, coniferous trees, etc., can be frozen to stone hardness without losing their vitality. According to Chodat, the spores of *Mucor mucedo* thus stand cooling to —110 deg. Cent. while certain diatoms, according to Pictet, can even be cooled without any lasting damage down to —200 deg. Cent. On the other hand, the tubers of potatoes, tobacco and pumpkin plants and the young leaves of the vine and nut-tree are nipped by the frost as soon as their temperature falls below zero.

Dr. H. Molisch, professor at the University of Vienna, has constructed a special refrigerator, by the aid of which the freezing of cells, tissues and vegetable organs can be examined under the microscope. This apparatus mainly consists of a double-walled wooden box, containing in the space between the two walls some insulating sawdust, to protect the interior against heat radiation. The interior of the box is lined with galvanized sheet iron and contains a receptacle for the microscope. The refrigerating mixture is introduced into the space between the inside wall and the microscope receptacle. The cover of the apparatus comprises an aperture allowing the microscope to pass and a hole receiving a sensitive thermometer, the bulb of which nearly touches the object to be frozen.

Before studying in this apparatus the freezing of cells and tissues, Dr. Molisch examined the freezing of inert colloid matter. A two per cent aqueous gelatine solution which at ordinary temperatures forms a tough jelly, behaves as follows at the moment of freezing: A number of minute icicles are seen to appear at many different points, giving off air bubbles and growing rapidly at the expense of the surrounding jelly, which loses its water more and more and finally degenerates into a highly complicated network of meshes extending between small ice particles. The previously homogeneous substance thus acquires a sponge-like structure, with ice particles interspersed through its gelatine skeleton. Similar results are observed with other colloidal substances, the process of freezing being invariably attended by a separation between the water and colloid, while the very numerous ice crystals gradually absorb the water. Emulsions, such as the milky juice of plants, show a similar behavior, and the freezing of salt solutions is likewise attended by a separation between the water and the dissolved substance.

According to the above, similar phenomena were to be expected in vegetable cells which, as is well known, contain colloids as well as emulsions and salt solutions. An amœba kept in the apparatus at the temperature of —9 deg. Cent. for instance undergoes a slackening and, after some minutes, a complete cessation of its movements. After about 25 minutes, the surrounding liquid freezes, and the whole of the amœba congeals in the form of an irregular filament containing a number of minute icicles. This amœba, even after thawing up, is quite different in appearance from the living amœba. The protoplasma skeleton with its ice particles in fact remains nearly unaltered, while the cavities previously filled with ice and snow contain water. Thus the amœba is killed by the frost.

Generally speaking, the freezing of a cell may occur in three different ways:

1. The cell really freezes and congeals, forming some ice in its interior, within the cell walls.

2. The cell is nipped by the cold without being itself frozen. In this case, which is of very frequent occurrence, the water escaping from the cell freezes on the outer surface of its walls. The cell which frequently shrinks to an enormous extent surrounds itself with a narrow ice capsule formed from its own contents.

3. The phenomena enumerated under 1 and 2 may take place simultaneously in a given cell; whichever the process of freezing, it always entails, as in connection with inert matter, a very considerable and sometimes enormous loss of water.

As regards the freezing of vegetable tissues, it was previously thought that the ice formed in the interior of the cells breaks and accordingly destroys these latter. However, it should be understood that the ice is generally formed outside rather than in the interior of the cell. The membrane being soaked with water, the outside water layer is the first to freeze, and this ice layer grows at the expense of the cell water, so that icicles of an inch or so can be found between the cells. The salt contained in solution of course lowers the freezing point, while on account of supercooling, congelation often occurs at even lower temperatures than correspond to the composition of the cell water.

As regards, finally, the factors determining the fatal effects of frost, two different theories were previously held. According to one theory which has been refuted by recent research, the death of plants occurs, not in the frozen condition but during the thawing. According to the other theory, which has been suggested by Mueller, death by frost is a case of dehydration through the formation of ice. Dr. Molisch in fact has shown the withdrawal of water to be very frequently responsible for the destruction of vegetable cells. The withering of plants by the way is quite comparable in this respect to freezing, as the decay of leaves, flowers and roots is due to these organs requiring a certain amount of water to feed their cells. If the cell substance be deprived of this water its structure gives way, and death occurs. However, the withdrawal of water by freezing may also produce other lesions, such as the formation in the interior of the cell of highly concentrated and possibly toxic solutions, or the separation of dissolved substances. In the light of this theory, it will be readily understood that the different parts of a plant should be the more subject to freezing, as they contain more water. However, in some cases, freezing must be due to other causes, such as a minimum of temperature or secondary chemical reaction.

Though recent researches have greatly contributed to elucidate the mechanism of the freezing of plants, there are still many enigmatic points, especially the great diversities in the sensitiveness of plants to low temperatures.

Apparatus for Measuring the Velocity of Explosive Reaction

By Dr. ALFRED GRADENWITZ.

THE time required for the explosive decomposition of different materials employed in blasting and ballistics is a characteristic property of each particular material, and is of course exceedingly short, so that the products which are raised to a very high temperature are disengaged under immense pressure.

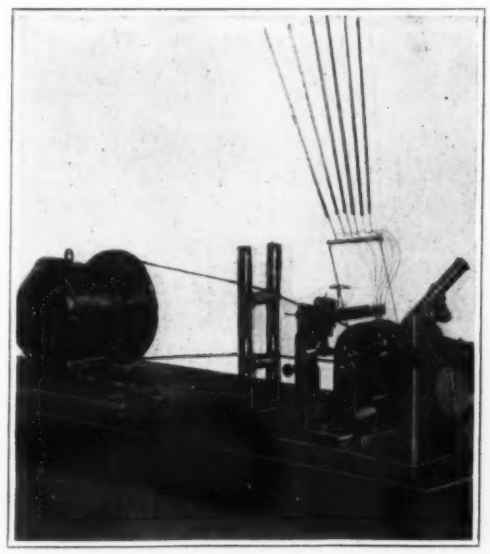
It is quite an important matter in technical practice to be able to determine as accurately as possible the time of explosion of different substances, and an apparatus which has recently been constructed for the Sprengstoff Aktien Gesellschaft Carbonit of Hamburg fulfills the requirements with a high degree of perfection. It is the invention of Dr. Mettegang and by its means the time of explosion can be measured to within one-millionth of a second.

The apparatus consists essentially of the following parts:

1. A smoked drum with platinum style pinion, micrometer and current interrupter.
2. An electro-motor.
3. A vibration tachometer.
4. Two induction coils.

The smoked recording drum with its accessories is the most important member of the apparatus. It is made of metal and has 500 teeth, each measuring 1 millimeter at its circumference. This drum is actuated through a belt transmission by the electro motor, at a speed giving a peripheral velocity up to 100 meters per second. The micrometer consists of a worm with each rotation of which the drum travels a distance of 1 millimeter. On this worm, which is made to mesh with the teeth of the drum, is mounted an index moving over a disk graduated into one hundred equal parts; the distance between two points on the drum can thus be read to within about one-hundredth of a millimeter.

The wonderful sensitiveness of this apparatus can be gaged from the following: Supposing the drum to cover a distance of 100 meters per second, 1 meter will correspond to 0.01 second, 1 millimeter to 0.00001 second and 1/100 millimeter to 0.0000001 second. The apparatus thus allows about one ten-millionth second to be measured. A microscope with cross-wires is used to gage the distance of the dots made on the drum above described. In front of the periphery of the drum are placed two or more platinum points which can be approached to a fraction of 1 millimeter.



This Apparatus Registers the Incredibly Short Time During which an Explosion Lasts.

The explosive to be examined is introduced into an iron tube 30 millimeters in diameter and about 3 meters in length at both ends of which are arranged conductors connected to the primaries of two coreless induction coils. The secondary circuits of these induction coils are connected with one pole each to one of the platinum points in front of the recording drum and with the other pole, to the bearing of the latter. The speed of rotation of the drum is gaged by means of a vibration tachometer.

The current derived from the mains or an accumulator battery is led through resistances constituted each by ten parallel-connected incandescent lamps, to the primaries of the induction coil and thence back to the current generator, the connecting wires traversing a series of cartridges to be fired. If now the primary current be broken by the explosion of the cartridges and the tearing of conductors, a spark will pass in each of the secondaries between the platinum point and the recording drum. On account of the oscillatory character of electrical discharges, these sparks are recorded on the drum as series of dots. As during the explosion of the cartridges a certain time elapses between the tearing of the two conductors, the origins of these two series of dots are situated at a certain distance apart, which distance corresponds to the speed of explosion of the material, in meters per second.

The same apparatus can be used for measuring the speed of projectiles.

The Origin of Radium*

Uranium Cannot Be Its Immediate Parent

By Frederic Soddy, F.R.S.

THE theory of atomic disintegration, which affords a philosophical explanation of radio-activity, was based on simple chemical observations of the regeneration of radio-active constituents in substances from which they had been chemically separated, and not, as has sometimes been asserted, upon any physical or chemical theories as to the nature of the atoms of matter. Only two of the large number of new problems originally suggested by this theory remain at present unanswered. One had to do with the nature of the ultimate product or products of the disintegration of the atoms of the two primary elements, uranium and thorium. This problem may be likened to the task of trying to find a meteor after its flight, when its energy is spent and nothing but the matter remains. Much indirect evidence points to lead as the final product of uranium, although no direct proof has been obtained, whereas for the case of thorium there is still no hint of the answer. The other had reference to the origin of radium. This element in the intensity of its activity, and therefore in the rapidity of its disintegration, resembles the short-lived active constituents uranium X and thorium X, while in the apparent permanence of its activity it resembles the primary radio-elements. Even the first rough estimates indicated that the period of average life of radium was not greater than a few thousand years. The present estimate, due to Rutherford, is 2,500 years. A few thousand years hence the radium in existence to-day will for the most part have disintegrated. Very little of the radium in existence at the time the Pyramids were being built can still exist. Hence arose one of the most interesting and crucial of the problems of atomic disintegration. Does the regeneration of radio-active constituents, observed in the cases where the period is short compared to the span of human life, apply also to radium—to an element, that is, with a definite spectrum, atomic weight and chemical character, filling a vacant place in the periodic system, and forming one of a family of common elements? After the separation of radium from a mineral does the non-radium part of the mineral grow a fresh crop with lapse of time, the quantity present before separation being the balance or equilibrium quantity when the rate of production is equal to the rate of supply? A somewhat similar prediction made with reference to the production of another well-defined element, helium, in the radio-active process had only to be tested, as it was first in 1903 by Sir William Ramsay and myself, to be proved correct. The question, however, of the origin of radium is still, in spite of many discoveries, not entirely solved.

At first sight the experimental trial of the view appeared easy. This problem is not analogous to the finding of a meteor after its flight is spent. The quantities of radium which can be detected and recognized unequivocally by radio-active methods are thousands of times smaller than can be detected even by the spectroscope, sensitive as the spectroscopic test of radium is. The first product of the disintegration of radium is a gas, the radium emanation, and the test for radium consists in sealing up a solution of the substance for a month, then boiling the solution in a current of air, and introducing this air into the electroscope. For the instrument employed, a millionth of a milligramme of radium would be rather an undesirably large quantity, while a few hundredths of this amount is the best suited for accurate measurement. The volume of radium emanation, measured at N.T.P., obtainable from one gramme of radium is only 0.6 cubic millimeter, a volume comparable to that of a pin's head. If a thousandth part of this quantity were distributed uniformly through the air of this room, estimated as 50,000 cubic feet, or about 1 2/3 tons by weight, and the electroscope were then filled with the air of the room, it would produce an effect much greater than any dealt with in the work to be described.

Since radium is found in uranium minerals and since uranium and thorium are the only elements

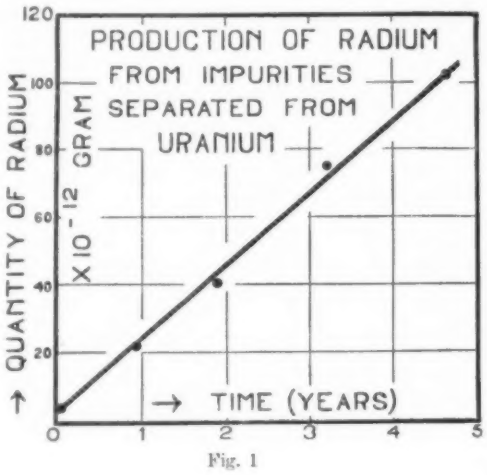


Fig. 1

known of atomic weight greater than that of radium, it was natural to suppose that uranium was the primary parent, in the disintegration of which radium results. Preliminary experiments nine years ago on a kilogramme of uranyl nitrate, purified from radium by precipitating barium sulphate in the solution, proved that uranium could not be the direct parent of radium. For in this case, from 100 grammes of uranium, the growth of radium should be readily detectable after the lapse of only a few hours. Whereas from a kilo-

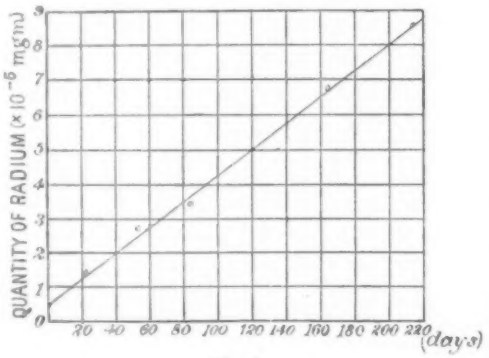


Fig. 2

gramme after 500 days, although a distinct increase of the quantity of radium was observed, it was at most only 1/1,000 part of what should have been formed. In the meantime, indirect, though conclusive, evidence that uranium was the primary parent of radium was obtained by McCoy, Strutt, and Boltwood, who showed that in all unaltered minerals there is a constant ratio between the quantities of the two elements, and this is what is to be expected if they are genetically connected. Unfortunately, this is still the only evidence available of the connection between the two elements. To account for the excessively slow growth of radium in the first uranium preparations studied it was necessary to suppose that between the uranium and radium an intermediate product existed of period of life great by comparison with the time of the experiment. Such a product would enormously retard the initial growth of radium. Its existence complicates what first appeared as a very simple problem in many other ways. It is no longer a question of simply detecting a growth of radium. It is necessary to measure the form of the growth-curve accurately.

In the first place this intermediate parent must be present in uranium minerals, and therefore, to greater or less extent, in commercial uranium salts. The mere separation of radium therefrom initially, as in the first experiment, is not sufficient purification. In addition every trace of the intermediate parent must also be separated, or a growth of radium will not prove that uranium is the parent. On this account, in conjunction with Mr. T. D. Mackenzie, a fresh series of experiments was begun in 1905, in a new laboratory uncontaminated by radium. Three separate quantities, each initially of 1 kilogramme of uranyl nitrate, were purified by repeated extraction with ether, which was considered to be the method most likely to separate all the impurities, not merely the radium. Observations on these preparations have now been in progress for six or seven years. At the same time a portion of the impure fraction separated from the original material was sealed up, freed from initial radium by the barium sulphate method, and tested for radium from time to time along with the pure uranium preparations. The diagram (Fig. 1) shows the growth of radium in this impure fraction. The unit used for expressing the quantity of radium is 10^{-12} gramme. It confirms unequivocally the original observation that a substance is present in commercial uranium salts capable of generating radium and not removed from it by the barium sulphate method used first for separating the radium, but separated, at least mainly, by the ether method.

In the meantime a cognate discovery of first importance was made by Boltwood, in America, who proved that actinium preparations obtained from uranium minerals, and initially free from radium, grow a fresh crop of radium with lapse of time. The growth is not by any means a very minute one as in my experiments, in which the growth can only be put beyond all doubt after the lapse of years. The growth of radium from constituents separated from minerals can be readily detected and measured in a relatively short space of time. The curve shown (Fig. 2) is taken from a paper by Keetman (*Jahr. Radioact. Elektronik*, 1909, vi., 270), who has worked upon this parent of radium in Germany. Although the total quantity of radium represented by this curve is only nine millionths of a milligramme, it is enormous compared with that shown by the other diagram (Fig. 1), in which the quantity of radium produced in a period about eight times longer is nearly a hundred times less. Further work on this parent of radium proved that it was not actinium, but a new radio-element admixed with it, which Boltwood called ionium. It is radio-active, and its radiation consists entirely of α-rays of very low range. The chemical nature of this ionium is absolutely identical, so far as is known, with that of thorium, and it cannot be separated from it. On the other hand, it is easily separated from any mixture, however complex, by adding a trace of thorium and separating and purifying the latter. It is interesting to note that no fewer than three at least of the known radio-elements—ionium, radio-thorium, and uranium X—are absolutely identical in chemical properties with thorium. This complete similarity with known elements is one of the features of the chemistry of radio-elements.

Returning to the experiments with the uranium solutions purified by ether (Fig. 3) shows the growth of radium therein. The three curves labeled I., II., III. refer to these preparations. No. III. was the last prepared, after experience with the others, and contained both the greatest quantity of uranium and the least radium initially. No. IV. refers to a much later experiment with no less than 6 kilogrammes of uranyl nitrate, purified by repeated crystallization in the course of other work. In all, there has been a distinct growth of radium, but it is so small, and the period over which the measurements extend is so prolonged, that the errors of the individual measurements are relatively great. The general scope of the curves, as indicated in the figure, is, however, probably not far wrong. A conservative view to take is that in all cases the curves are straight lines. There is some indication in No. I. of an increasing slope, but it is negatived by the evidence of Nos. II. and III.

The quantity of uranium in the four preparations differs widely. In Fig. 4 the curves are replotted in a different way to eliminate this difference. The ordinates

* From a discourse delivered at the Royal Institution on Friday, March 15th, and published in *Nature*.

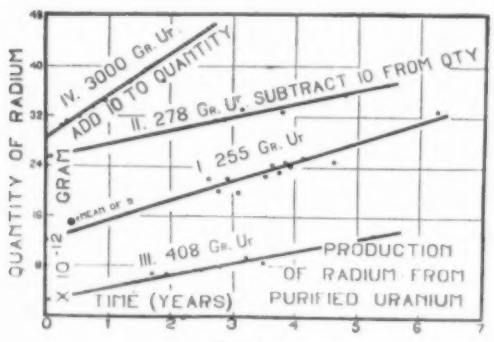


Fig. 3

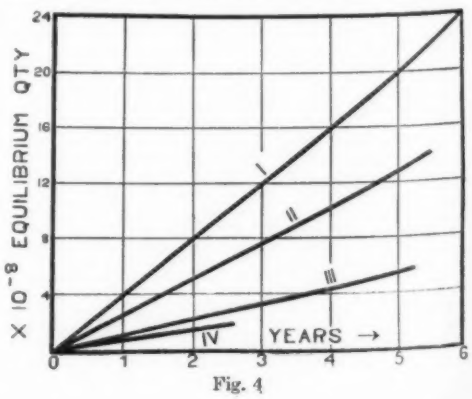


Fig. 4

represent the quantities of radium formed in terms of the amounts of radium in equilibrium with the uranium. The equilibrium amount is the amount that theoretically should be formed after the lapse of sufficient time, if uranium is the ultimate parent of radium. It will be seen that the slopes of the four curves are all different and diminish in order, the growth in the first being the greatest, and in the last, after all the experience in methods of purification, the least. This is additional evidence that, so far, the radium formed is derived, not from the uranium, but varying infinitesimal quantities of ionium unremoved by the purification processes.

Taking No. III. as the best of the first batch of preparations, the growth of radium therein is only about 1/30,000 part of what would have occurred if uranium were the direct parent of radium. Some idea of the minuteness of the quantities of radium indicated by these curves can be got by the following consideration. Radium bromide at its present price costs about $80 per milligramme. For the element, radium, this is at the rate of $3,750,000 per ounce. Fig. 3 represents a diagram 2 feet high. To represent one cent's worth of radium on this scale would require a diagram more than 3,000 feet high, whereas to represent Keetman's curve (Fig. 2) would require one as high as St. Paul's Cathedral.

These results, therefore, confirm absolutely the view that uranium does not produce radium directly. As Rutherford first showed, if ionium is the only long-lived radio-element between uranium and radium, the growth of radium from uranium must initially be proportional to the square of the time, and should be represented by the equation $R = 6 \times 10^{-8} \lambda T^2$, where R is the radium formed per kilogramme of uranium, T is the time in years, and $1/\lambda$ is the period of ionium. Hence, if uranium is the primary parent of radium, it is to be expected that the rate of growth of radium from the preparations will increase as time goes on according to some power of the time higher than unity. As Fig. 3 shows, there is still no evidence of this increase of slope in any of the preparations. This indicates, either that the period of ionium must be enormously long, or that several intermediate long-lived members intervene. If ionium is the only intervening member a *minimum* possible limit to its period may be arrived at by applying the above equation to the results. If it is assumed that the growth observed is due to uranium and that no ionium was initially present, the minimum periods calculated in the several experiments are as follows: No. I., 28,000 years; No. II., 41,400 years; No. III., 80,000 years; and No. IV., 69,200 years. Since, in all, certainly some of the growth is due to ionium initially present, the period of ionium must certainly be greater than the longest of these periods. We may safely conclude, if ionium is the only intermediate member, that its period is *at least* 100,000 *years*. This is forty times longer than the period of radium itself.

Entirely independent confirmation of this conclusion was obtained in another way. The gap in our knowledge is, strictly speaking, not between uranium and ionium, for the direct product of uranium is well known, and is called uranium X. It gives β-rays alone in disintegrating and has a period of only 35.5 days, so that in all the preceding work it has not been necessary to take it into account. It would retard the growth of radium inappreciably. But, if the view is right, the product of uranium X must be ionium, which gives α-rays. Concomitantly with the rapid decay of the intense β-rays of uranium X there should occur a growth of α-rays due to the ionium produced. Whether these α-rays can be actually detected will depend on the period of ionium. From experiments on the uranium X separated from 50 kilogrammes of uranium nitrate no growth of α-radiation, concomitant with or subsequent to the decay of the β-radiation, could be detected, and from these negative results the minimum period ionium can possess, if it is the only long-lived intermediate product, is 30,000 years.

The question arose whether by any means an upper limit, or maximum value, for the period of ionium could be assigned. By the law already discussed there must be many times as much ionium as radium in uranium minerals, and if the actual ratio were known the period of ionium could at once be found. For example, if the period were 100,000 years, there should be 12.5 grammes of pure ionium per ton of uranium. Auer von Welsbach, in a masterly chemical separation of the rare-earth fraction from 30 tons of Joachimsthal pitchblend, separated a preparation, which he described as thorium oxide, containing ionium, the activity of which was measured by Meyer and von Schweidler. To obtain a maximum estimate for the period of ionium, I assumed that Welsbach's preparation was in reality pure ionium oxide (which it certainly was not, as it gave the thorium emanation), and so I obtained the period of a million years as the upper possible limit. In proportion as the percentage of ionium oxide present is less than 100 per cent, this period must be reduced.[1] Thus we have fixed the period of ionium as between 10^5 and 10^6 years, if ionium is the only intervening long-lived member.

Quite recently a method has been devised for calculating the period of ionium from the range of its α-particles, which is based upon an empirical mathematical relation holding between this range and the periods of the substances giving α-rays in the case of the other members of the series.[2] The most recent estimate by this method is about 200,000 years, which may be accepted provisionally as the most probable at the present time. If this is correct, there should be 25 grammes of ionium per ton of uranium in minerals. A variety of evidence thus leads to the conclusion that to detect the growth of radium from uranium either still larger quantities of uranium or still longer time is necessary. Even after ten years, that is, at the end of 1916, if the period of ionium is as estimated, the uranium in No. III. preparation should only have produced 12×10^{-12} grammes of radium, which is rather less than half the amount that will then have been formed by the ionium initially present. Nos. I. and II. preparations are very much less favorable. But it is interesting to consider No. IV. preparation, which, though only 2.6 years old, has more than seven times as much uranium as No. III. From the present slope of the curve it appears to have little more than one half as much ionium, relatively to the uranium, as No. III., whereas the relative initial quantity of radium is about twice as great as in No. III. After eight years, that is in 1917, the quantity of radium produced from the uranium should be about equal to that which will have by then been produced from the ionium present. A distinct upward slope should be detectable in the growth curve some time before this. But this is the best, if the estimate of the period of ionium assumed is correct, that the present set of experiments can offer to the solution of the problem. With the experience already gained, especially in dealing with large quantities of uranium and in the methods of measurements of the minutest quantities of radium, there should be no difficulty in obtaining and dealing with sufficient uranium, say 20 kilogrammes, of the requisite degree of purity as regards ionium and radium, to determine directly in a few years the period of ionium from the growth curve provided it is not greater than 200,000 years.

A favorable opportunity is being awaited to initiate this large-scale experiment. It requires a small room to itself in a permanent institution uncontaminated with radium, and some guarantee that once installed the preparations will remain undisturbed for a reasonable term of years, and that the measurements will be continued in a comparable manner should the period of life of the original investigator prove insufficient. It is not enough to set aside a quantity of uranium for our successors to see if any radium has grown in it. It is essential that the exact form of the growth curve should be known before the problem in question can be fully answered. There *may* be more than one long-lived intermediate product between uranium and radium. However, such indirect information as has been acquired as to the life period of ionium indicates that it alone is sufficient to account for the present results as regards the absence of growth of radium from uranium.

[1] Soddy, *Le Radium*, 1910, vii., 297.

[2] Geiger and Nuttall, *Phil. Mag.*, 1911, xxii., 613; 1912, xxiii., 439.

The Pod-Septum of Catalpa

A Criterion for Distinguishing the Hardy Variety

THERE are several species of catalpa trees indigenous in this country, which are more or less useful for small lumber, such as railroad ties, fence posts, and the like. In particular the "hardy catalpa" (*Catalpa speciosa*) is valuable and superior to the common catalpa (*Catalpa catalpa*) and it is desirable to have some ready means of distinguishing the two. Unfortunately this is not altogether an easy matter. A criterion which has been furnished in a recent publication of the Society of American Foresters by W. H. Lamb, would therefore prove very valuable. We reproduce here the main substance of Mr. Lamb's paper.

"Many plant species are not distinguished by one character alone, but by the combination of numerous small but constant differences. This is true of our two species of catalpa. Very unlike in silvical qualities, these two forms are extremely similar in botanical characteristics. In fact, the leaves, flowers, seeds, and even the pods, are so nearly alike that the identity of a specimen may often prove puzzling, even to one who has an excellent knowledge of our forest trees.

"It is practically impossible to distinguish between the two species of catalpa from the leaves alone. It is true that the leaves of common catalpa are stronger scented and not quite so long pointed as those of hardy catalpa, but these distinctions are very slight, and being entirely relative, are practically of no value.

"The flowers furnish a better means of identification. Those of common catalpa are thickly spotted on their inner surface, and the lower lobe of the corolla (the white part of the flower) is not notched, while those of hardy catalpa are not so thickly spotted and the lobe of the corolla is slightly notched. But catalpa flowers are fragile and only available for a short time in the spring, and even then such distinctions are of little value except as a means of comparison.

"Identification from the seeds alone is most difficult. These two species have seeds so very much alike that although the two forms may often be separated when placed side by side, yet with a single specimen at hand specific identification is most precarious.

"The pods are essential for positive identification; but even with these it is difficult to distinguish the species because of their extreme variability in size. In general the pods of hardy catalpa are larger than those of common catalpa. However, pods of common catalpa are found practically as large as the largest of the hardy catalpa. According to Dr. Sargent, the pods of hardy catalpa are 8 to 20 inches long and those of common catalpa 6 to 20 inches in length. So the size of the pod is absolutely of no value as a distinguishing feature.

"There is, however, one character which seems to be entirely dependable—the septum.

"The septum is the long, wrinkled partition in the pod, along which the seeds are arranged. This septum, or pod-partition, may be flat or rounded in general outline, and this variation in shape furnishes a valuable means of distinguishing hardy catalpa.

"The septum of hardy catalpa, an enlarged section of which is shown diagrammatically by Fig. 1, is rounded in general outline. The septum of common catalpa (Fig. 2) is only thickened along the middle. On account of the fact that the septum is very irregular and not of uniform thickness throughout, places may be found in the septum of hardy catalpa that are considerably flattened, approaching the shape shown by Fig. 2, but no pod of common catalpa has ever been observed by the writer with a septum as thick in any place as shown by Fig. 1.

"This important distinction has never been sufficiently emphasized, and will, it is believed, prove to be the most dependable single factor in the identification of hardy catalpa."

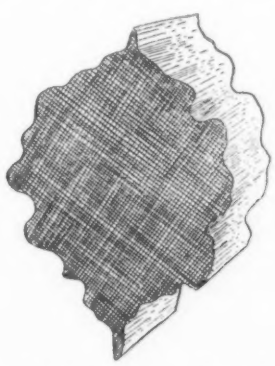


Fig. 1.—Pod Septum of the Hardy Catalpa.

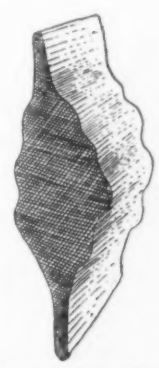
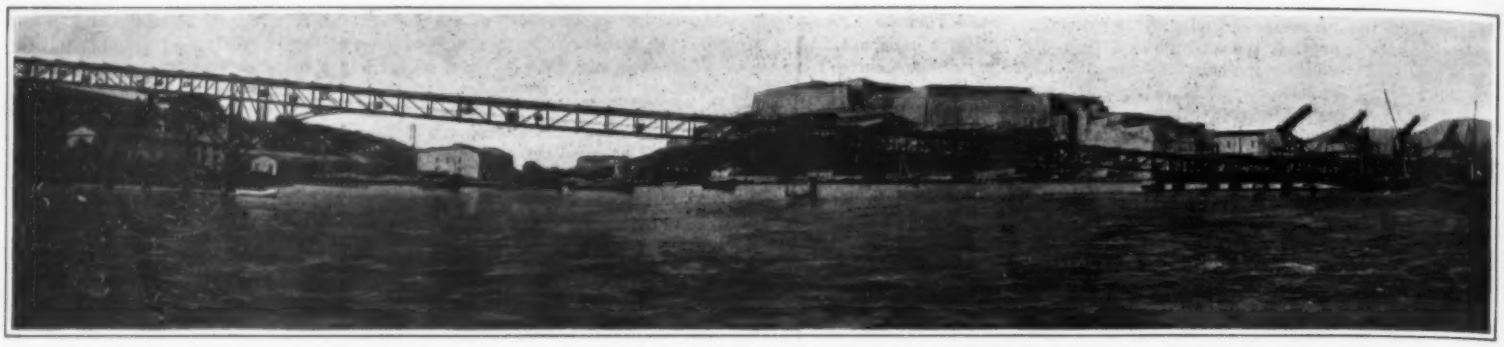


Fig. 2.—Pod Septum of the Common Catalpa.



Transport Structure and Four Cranes at Portoferrajo on the Island of Elba.

The Elba Iron Ore Loading Plant

Continued from first page

The above view shows the chief port of Elba and in our illustrations may be seen the method of loading the vessels, the pier in the sea as seen from above, the transport structure and four loading cranes at Portoferraio, while the last two photographs show the iron ore loading station and commencement of track at this station on the Island of Elba.

The ore is a hard, spathic, brown iron-stone of a compact or crystalline nature, frequently of a fibrous structure with ochre veins, and is obtained from open workings, particularly in Giove Portello, where the latter class of ore with an iron content of about 80 per cent is found.

The ore at Rio Albano has only an average of 40 per cent, the output being about 800 tons per day, while in Giove Portello it reaches as much as 1,200 to 1,400 tons. There are 2,000 men engaged in the district, mostly from the villages of Rio Marina and Rio Alto.

The ore is transported within the mines on pit railways, which at Rio Albano are worked by horses, while in the Giove Portello district locomotives are employed to move the trains consisting of trough tipplers.

The only difficulties hitherto experienced were the conveyance of the ore down to the coast and the loading into vessels of 3,000 to 4,000 tons for the transport of the richer ores to Naples and Piombino, or sailing vessels of 150 to 600 tons for the lower grade ores going to Portoferrajo. These difficulties arose not only from the transference of the ores from the shore to barges, and their conveyance to vessels in the open sea, but also from the fact that, for the ores to be loaded in deep water, the sea on this exposed coast is only sufficiently smooth for about 150 days in the year.

The ores have to be loaded in as large quantities as possible in a limited time, for which, as a rule, sufficient ships were available. No serious difficulties were anticipated in the traffic until the Bagnoli blast furnaces, near Naples, approached their completion.

The problem was then taken up of loading the ships by mechanical means, in order to forestall any possible shortage. The mechanical loading appliance was required to have a capacity of about 200 tons per hour, so as to take full advantage of the few days of favorable weather.

It was also necessary to carry the loading plant out into the open sea for a considerable distance, as the shallow water would only allow the vessel to approach the coast at a distance of 100 to 200 yards.

As the most economical solution of the loading problem an aerial line and a loading pier with two similar lines for Rio Albano and Giove Portello were constructed.

The ore is thrown from the pit-tubs into hoppers at the mine, from which the ropeway cars are loaded. These hoppers are designed in masonry work with inclined floors for the pockets, 12 being provided in Rio Albano with a total length of 167 feet and 24 in Giove Portello with a total length of 265 feet, from 6 of which the ropeway cars are simultaneously loaded by means of escape gates.

These cars which are designed for a load of 20 hundredweight of ore are then weighed and automatically registered by 3 automatic scales fitted for this purpose on 3 parallel branches in the suspension railway sections of each loading station, after which they are pushed from the station on to the open track, whereby they are coupled automatically to the traction rope in continuous motion on leaving the station.

The open track consists of steel wire ropes anchored in the loading station, on which the carriages of the cars run. The station Rio Albano is seen from above, in frontispiece, with the crossing from the suspension rails on to the carrying ropes. The carrying ropes are carried on the open track by iron supports, and the line has various heavy gradients, on which the Bleichert coupling apparatus clips the traction rope with absolute safety. On the shore several supports are erected, between which the carrying ropes are deflected and spanned by

Method of Loading the Vessels.

means of heavy weights. In this manner it is quite impossible to overload the ropes of the line.

The supports from the Rio Albano line which carry the fixed suspension rails forming the continuation of the carrying ropes over the sea are arranged on the pier, as indicated in our frontispiece. The traction rope is also guided along this section, and is deflected at the end of the bridge construction by a deflection sheave.

The height of the suspension line above sea-level is 42½ feet, so that vessels can be conveniently loaded from above at any state of the tide. The loading pier for the ships has a width of 10 feet expanding 100 feet from the end, to a platform 30 feet wide. Here the ships are loaded by portable chutes, into which the ropeway cars tipple automatically. The hoppers for the transference of the ore are portable, the chutes being raised by a slewing crane and moved to one side, so that they can be easily pushed past the vessels lying at the pier.

There is only one chute on each side of the pier and the cars on arrival discharge their contents into one or other of the chutes in accordance with the position of the detent, so that the traffic can proceed without interruption. The passage of the cars round the return sheave at the extremity of the bridge is automatically effected without the cars detaching from the traction rope, and no hands are therefore required on the bridge to attend to the line, except a man to shift the chute.

The Giove Portello plant was designed similarly to that of Rio Albano, the latter having a length of 1,000 feet with a fall of about 160 feet. About 200 cars are handled per hour, which follow successively at intervals of 18 seconds, so that with a speed of the traction rope of 4 feet per second, the distance between the cars is about 70 feet. There are always 28 cars on the track, and an additional 6 cars in the loading station for loading and weighing.

There is a fall in favor of the traffic, so that an excess power of 30 horse-power is produced on the line. This is utilized to drive a pump for the ore washery, the uniformity in the speed of the line being maintained by an automatic brake regulator.

The Giove Portello line has a length of 395 feet, producing a surplus power of 70 horse-power neutralized by means of a wind-sail brake and the capacity of the two mines amounting to 200 tons per hour is very high, although this has also been previously reached on a number of wire ropeways.

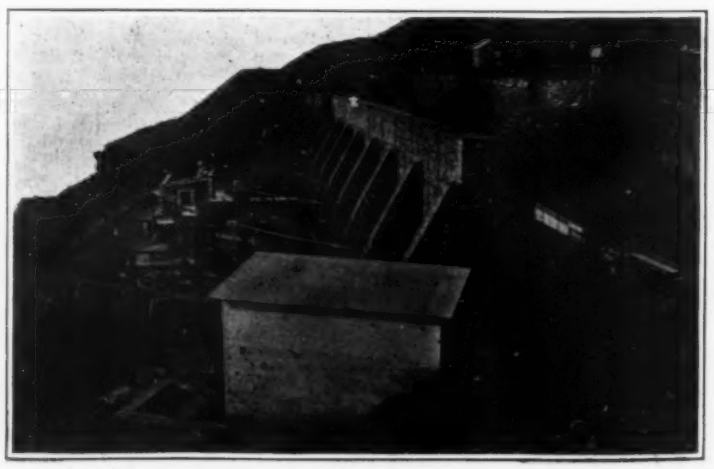
As compared with a normal ropeway with a capacity ranging between 50 and 100 tons per hour, the distance between the cars is short, but the intervals between them of 18 seconds on the Rio Albano and Giove Portello lines is not the maximum attainable.

On the ore loading line at Vivero, Spain, where 250 tons per hour are handled, the cars follow one another at intervals of 14.4 seconds, but it will hardly be possible to make a further reduction in this direction, and other measures must therefore be taken if the capacity of aerial railways is to be still further increased, for instance, double cars or double ropeways would have to be resorted to. The employment of four-wheeled carriages for heavier single loads with a reduced wheel pressure has not yet appeared necessary on the lines described on the island of Elba, although this has been found advantageous on other plants with large capacities.

The Bleichert double carriage for the ship-loading line is in use at the plant of the Societe des Mines et Carrieres de Flamanville. This plant has a double-track type and handles 500 tons per hour with single loads of 1½ tons. A special characteristic of this carriage, which distinguishes it from the older method of attaching loads to 4 wheels, is the coupling apparatus designed on the system of the Bleichert "Automat" which utilizes the entire weight of the car and the load for the clipping action.

Whether double cars are to be preferred to the single ones will have to be demonstrated by experience, as details are still lacking regarding the conditions of deterioration in the ropes.

Commencement of Track at Loading Station.



Iron Ore Hopper and Loading Station.

The New Los Angeles Water Works

A World's Object Lesson

By W. H. Ballou

WHILE London is taking a section of its increased water supply in Wales, over 200 miles distant, Los Angeles, Cal., is reaching out 240 miles for its source, or perhaps at this moment, 10 miles farther than its distant rival for honors. But London is not through with its reaching-out process and may never be if it keeps up its wonderful growth. If New York city had gone originally to the Adirondack Lakes of 3,000 feet altitude, at a distance of approximately 200 miles, it could have brought down unlimited supplies of water by similar gravity systems at a fraction of the cost it is now expending, beside selling water enough *en route* to make a big annual profit. Los Angeles is to get an unlimited mountain water supply for the comparatively insignificant sum of $24,500,000. Of this it will use seven times as much annually as Boston, which paid over $40,000,000 for its system. Ancient Rome perfectly understood the cheapness and utility of a long distance gravity system and projected its great aqueduct into the far away mountain sources, much of it still standing as originally constructed.

The Los Angeles works, to be completed in June next, comprehended an open canal, a lined canal, closed conduits and tunnel sections. None of the features are new. Of the four types, the lined canal is most interesting and most modern, but it is a feature generally exploited by the United States Reclamation Service in its irrigation engineering and probably originated there. The water way commences in the mountainous region of Inyo County, where the Owens River will be its principal source. It passes through a mountainous and desert country at present sparsely populated. There were no towns to destroy nor railways to reconstruct as in New York. Its first serious problem was the transportation and maintenance of laborers. Fortunately, the California and Nevada Branch of the Southern Pacific Railway hastened construction at the right moment to reach the high Sierras and provide a new main line of its system, solving this problem at the outset. With both railway and water works completed, the desert country is expected to rapidly settle up and pay the city the cost of its enterprise and a profit in the sale of water for irrigation purposes.

Concrete Aqueduct in Owens Valley, Forty Miles Long.

One of the Tunnels Through Which the Aqueduct is Carried.

The open canal section is 21 miles long, an unlined ditch running through the alluvial bottoms of the Owens River Valley. The district is prolific in water bearing lands, permitting direct percolation into the canal. Other sources are the Great Black Rock Spring, several mountain streams and a large artesian basin, defined by driving wells. The connecting canal is 40 miles long, the sides and bottom of which are lined with concrete. The next section is of covered concrete, 98 miles long. The open sections are on highlands only, blending into covered sections where the line reaches the desert. The open line is 35 feet wide, diminishing to 10 feet diameter at the covered sections. The larger open sections enable the city to store in huge reservoirs the flood waters and extra natural supply which exceeds the daily demand. The tunnel section is 43 miles long. Rapid work was done on it as no water was encountered. In consequence, the cost of construction decreased gradually as the work proceeded. Where narrow canyons and deep valleys were encountered, concrete flumes were inserted. Where the depressions were of considerable width, siphons were used. There are 12 miles of the siphons. They are constructed of concrete, having a 9-inch shell, at a cost of $5 per foot less than the steel siphons forming sections of the new Croton water works. The longest concrete siphon is 955 feet in length and has a head of 65 feet altitude. There are 4 storage reservoirs so far built in the mountains, of enormous size, ranging from 4 to 7 miles in length, with dams up to 140 feet in length. In brief, they are inclosed valleys in which will be locked up vast stores of water.

All of the concrete used was made from the materials excavated. The excavations were done with the latest and most powerful types of steam and electric power shovels, working with great rapidity. The brilliant achievement of Los Angeles, in constructing a money-making muncipally owned water supply, must be an object lesson to the world and generally followed in many of its features.

Silk Dyeing

THE manufacture of silk has grown to enormous proportions in the United States within the last decade, until now this country leads the world in this important industry. The dyeing of silk has kept pace with its manufacture.

Silk is of various kinds and qualities and practically all of it is dyed before it is woven, even the white shade. That known as "organzine" is made by the union of two or more single threads, twisted separately in the same direction. It is used chiefly for warp threads. The "tram" silk is made by twisting two or more single threads, which are then doubled and again slightly twisted. It is used for the woof thread in weaving. Single silk is not twisted or doubled at all. Cloth produced from this kind of silk possesses a softness and brilliancy not obtainable in that made from twisted silk. Pongee and chiffon are familiar fabrics made from single threads.

In dyeing silk the first process is that known as "stripping," or removing all or part of the natural gum which it contains. In stripping organzine or tram all of this gum is removed. In what are known as "souples," from 5 to 8 per cent is removed and in écru less than 5 per cent. The stripping is accomplished by washing the silk thoroughly in boiling olive oil soap water for several hours. It is then removed and a bath of warm water is given, after which it is treated with a dilute solution of muriatic acid.

In the stripping process the silk loses considerably in weight and this must be restored before it is dyed. Unfortunately, however, few dyers are content with restoring only this lost weight, but add to it, so that the silk is sometimes made to weigh twice as much as it did before stripping.

Two general methods are employed in weighing—treatment in a solution of nitrate of iron, of about 30 degrees Baumé scale—or in a solution of bi-chloride of tin of 26 or 27 degrees Baumé. The silk is suspended in either of these solutions for about an hour at a time, then removed, thoroughly washed, dried in a hydro-extractor and the treatment renewed, until the desired weight is secured.

The nitrate of iron bath not only gives weight, but also acts as a mordant to hold the color, by chemically combining with the dye which the silk is afterward given. After each bath of bi-chloride of tin the silk is worked for an hour in a dilute solution of phosphate of soda, with just enough ammonia added to neutralize the acidity. This also acts as a mordant. The silk is sometimes given a bath of sulphate of alumina, after the weighting is completed, for the purpose of further mordanting and is then worked in a solution of silicate of soda, of 1 to 5 degrees Baumé which gives additional weight.

The principal black dyes used are logwood and fustic; the former for heavy weighted silk and the latter for the lighter, or "pure dye" silks. Sometimes the silk is first "blued" in a bath of permanganate of potash according to the shade desired, and sometimes placed directly in the dye bath. The silk is worked in a hot solution of either of the dyes, by being suspended on wooden rods placed across a wooden box about 30 feet long, 3 feet wide, and 3 feet deep, in which the dye liquor is contained.

The skeins of silk are moved backward and forward in the bath and frequently turned. This process is continued for several hours until the silk has attained the proper shade. It is then removed, given a bath in a dilute solution of carbonate of soda and washed in two waters. It is then "finished" in a bath of pure olive oil and lemon juice, which treatment readily gives it the required luster.

In color dyeing the coal tar dyes are principally used, according to the shade desired. The silk is placed in a bath of liquor which has been used in the stripping process, to which a small amount of the dye is added. It is then worked rapidly for about fifteen minutes, taken out and another small quantity of dye added. In this way the silk is gradually worked up to the required shade which often requires many hours. Should the color prove too dark the silk must then be given a bath in dilute ammonia water to remove some of the color and the process repeated until the exact shade required is obtained. It is then finished as in the case of the black dyed silk.

Scientific Problems Solved Within the Last Quarter Century.

THE German periodical *Prometheus* from which we have frequent occasion to quote is approaching its twenty-fifth year, and Prof. Witt, in an editorial note, takes occasion to review briefly some of the principal achievements of science and industry recorded within the past quarter of a century during which the journal has been in existence. He remarks that at the time of its birth there were a number of problems calling for solution, which the practical men of those days were inclined to look upon as food for the dreamer and visionary, rather than as subjects for the serious inventor to consider. Subsequent events have shown that the pessimism with which these problems were originally viewed was unfounded. Among the problems of this kind which have seen their solution within the period in question Prof. Witt quotes the following: The dirigible balloon; the heavier-than-air flying machine; submarine navigation; the attainment of the North Pole and of the absolute zero of temperature (which, as our readers know, has been reached to within a little over 1 deg. Cent.); wireless telegraphy, with the possibility of communicating from the land with ships at sea, and from ship to ship; the transmission of photographs by telegraphic means; and lastly the photographic reproduction of objects in their natural colors. As regards the attitude that was taken toward such problems twenty-five years ago, contrasted with the very much more optimistic views held to-day in reference to scientific problems, Prof. Witt points out that the former pessimism was really better founded than may now appear; for while the problems have been solved in the interim, they could not have been solved solely with the means at the world's disposal some twenty-five years ago; for their solution a number of intermediate steps had first to be made, before problems themselves could successfully be attacked. Perhaps, after all, the main lesson which we have been taught by past events, is that it is never safe to make negative prophesies as regard the possibilities of solving scientific problems.

The Abuses of Our Patent System*

Where Reform is Needed

By L. H. Baekeland

A RECENT decision of the Supreme Court (Sidney Henry et. al., v. A. B. Dick Company, March 11th, 1912. No. 20, October Term, 1911) upholding the right of patentees to dictate under what conditions a patented article shall be sold, or shall be licensed, has become the object of much criticism. One of our newspapers repeats the comment, that this decision could be interpreted to its extreme limits so as to mean that "it would enable the patentee of a window frame to dictate that all the material of a house in which the frame was to be used must be procured by him." But that argument overlooks the fact that nobody is compelled to buy that particular patented window and that the public-at-large can purchase any other window frame not patented, or of which the possession is not submitted to any restrictions. The Supreme Court decision simply means that the owner of a patent, in selling or licensing under it, has the same privileges that the owner of any other private property has. For instance, the proprietor of a lot can sell it with the restriction that if any house is to be built on it, the materials for this building shall be purchased from him. It all depends whether the purchaser is willing to submit to these terms or prefers to forego acquisition under such restrictions. To assail this decision of the Supreme Court, is to deny the elementary rights of private property, or to deny that a patent is private property.

Justice Lurton, in expressing the majority opinion of the Supreme Court, very correctly says: "When the patent expires, the public will be free to use the invention without compensation or restriction."

Outside of this limitation, why should restrictions be put upon ownership of patents, which do not exist for other forms of private property? An invention is the creation of something which did not exist before. Is the creator of this invention not entitled to undisturbed ownership, at least for a short period of 17 years, when the ownership of real estate, or other private property is undisturbed and continues forever?

And yet, real estate always existed long before it got in the hands of private owners. Its mere possession does not imply any special merit, nor does the private ownership of real estate confer any benefit upon the community. Nevertheless, real estate can be left idle at the whim of the owner, who in the meantime benefits by the enhanced value, the unearned increment, conferred upon his property through the enterprise of the community at large, and more especially by the enterprise of his immediate neighbors, who take the trouble and the risk to develop their own real estate, while he just remains inactive.

So that, in this and many other ways, the owner of real estate, or other private property, has an incomparably greater scope of unquestioned property rights than a patentee. Furthermore, these rights do not cease after 17 years, but continue forever.

It is a significant fact that in many cases, the persons who object most to patent rights are just those who have lived in surroundings where industrial or intellectual development is least apparent.

In some parts of the country, the word "patent" is scarcely known, and the conception of a higher class of property than that which is merely acquired by inheritance or money purchase is difficult to understand. On the other hand, the conception of intellectual property rights is one of the symptoms of a higher civilization.

I may point out on this occasion that the little State of Connecticut takes out more patents than all the Southern States together.

Most people imagine that patent laws are for the exclusive benefit of inventors, and this regretable mistake leads to many misunderstandings. Were this opinion correct, patent laws would mean class legislation, and would be as unfair, as undemocratic, as unwholesome, and as dangerous as any other class legislation.

But the patent laws, as framed under the Constitution of the United States, are primarily conceived for the benefit of the nation. No country has benefited more by its patent system than the United States. Compare the tremendous industrial development of such nations which have liberal patent laws, like the United States, Germany and England, with that of the Latin countries, where patent laws are less favorable to the inventor.

There is one civilized country, Holland, which until recently had no patent law whatever, and allowed the unrestricted use of any invention. This ought to have been the Paradise of Infringers; it was easy enough to use freely in Holland processes patented in other countries, and to distribute from there, infringing goods to all the countries of the world. Yet what was the result? Holland, with her highly developed commerce, her abundant money supply, with a race of intelligent and enterprising men, remained industrially undeveloped, and still ranks as one of the least industrial among the countries of the world. Why? Because there was no incentive to saddle oneself with all the risks and outlays of starting a new enterprise or of improving methods for manufacture, knowing beforehand, that in case of success, one's neighbor could simply do the same thing without any restriction whatsoever.

The fact that good patent legislation is for the benefit of the whole nation is too often lost sight of, and it behooves every good citizen of this country to help improve our patent laws and the administration thereof. A patent is simply a contract between the nation and an individual, the inventor. By that contract the inventor discloses to the community-at-large the results of his intellectual work; by doing so, he enables others to get acquainted with his work, and to improve thereon, and this stimulates further research, invention and enterprise. You will find that newly disclosed patents are usually followed in rapid succession by several improvements thereon, conceived by others, but patterned on the original invention. The inventor, in disclosing his secrets, confers a benefit on the nation, and the nation, in return, gives him for a rather short number of years the sole use of his invention—followed immediately afterwards by absolute confiscation in favor of the public. The period of this limited monopoly is none too long if we take into consideration the time it takes to develop an invention into commercial shape; in many cases, inventions reach the money-earning stage only after the patents on which they are based have expired. In the meantime, the disclosures made by the inventor stimulate enterprise and further invention, and induce the ideal form of competition by improvement most advantageous for the consumer—competition by improvement. So that, practically, the granting of a patent is simply a business contract between two interested parties: the nation and the inventor.

Up to this point everything goes well enough. Our patent laws, although not perfect, are generally considered as a model of good patent legislation; they were conceived in a broad and fair spirit, and the best answer to those who find too much fault with them is, that in all foreign countries, including Germany, whenever a modification has been made in their patent laws, the change has always brought them a step nearer to the American patent system.

The real trouble begins when this business contract between the nation and the inventor has to be enforced. It is there that the patentee does not get "a square deal." After the inventor has faithfully performed his part of the contract, and has disclosed his invention to the nation, the nation hands him a "gold brick."

Woe, indeed, to the poor inventor who tries to enforce his rights against wealthy infringers, aided by skillful lawyers. His well engraved United States patent parchment may then become his certificate of entrance to the poor house, or to the lunatic asylum. All this tends to discourage invention by independent individuals and paralyzes the stimulation of invention our Constitution intended to promote by the patent law.

In other words, although the patent law of the United States is about as fine a piece of good progressive legislation as was ever conceived, its enforcement in the United States courts is subject to so many uncertainties, complications, delays, and to such horrible expenses, that the man with limited resources is at an inexpressible disadvantage.

If any one asks my advice, whether he should take out a patent or not, my invariable answer is: "Can you find the money to defend your right in court? If not, do not waste any time or money on a patent."

Here, then, is an instance of a beneficent and well planned law, meant to be fair to everybody, and which through absurd rules of practice and procedure, as sanctioned by American courts, has entirely deviated from its purposes. Meant to stimulate research and industrial development, it has merely become a pretext of playing bluff against bluff, trick against trick, by skillful acrobats of the profession of law.

As our patent law is used now, it is certainly a God-send for large corporations, lawyers and experts.

About three years ago, one of the most successful law practitioners, a candid man, declared publicly before the N. Y. Section of the American Chemical Society that as he was about to retire from business he had no further hesitation in stating that in the many patent cases he had won for his clients, the latter seldom, if ever, got any settlements for damages, and if they did, it was a mere fraction of the fees he had collected from them for defending their case; he took the occasion to ridicule the absurd conditions prevailing in our courts, which make this possible. Some experts reap just as golden a harvest by this state of affairs. Not so long ago I overheard a chemist, whose specialty is to testify in patent cases, discussing with an opposing expert a patent case in which he was retained; his conversation was boisterous enough that any one present could hear it: "This is the most interesting patent we ever had in that line," he said. "Do you realize the fact that this means for you and me at least five thousand dollars a year for at least five years and . . . . ," he significantly added, "this will give us an opportunity to learn much organic chemistry?"

As for wealthy corporations, it has become obvious that the skillful handling of patent cases places them at an untold advantage against their smaller competitors. For them, a well organized patent department is a reliable machine, where money is the lubricant. This machine, in its slow-but-sure grinding way, can reduce to pulp any of the smaller competitors. For large corporations, the maintenance of such a machine with a staff of lawyers and experts, is merely a small side expense. By its aid, they can bluff their weaker competitors into quick submission. If this is not successful, they can drag out a patent suit indefinitely, until the weaker opponent, unable to bear the ever-increasing expenses, collapses and withdraws.

These tactics are well known and have been played successfully, whether it was to uphold a worthless patent, or to obtain immunity in case of infringement. In every case, the wealthy corporation is sure of the outcome of the game and plays "Heads I win, tails you lose."

Although these facts are sufficiently known by all who have practical acquaintance with patent litigation, the public-at-large is ignorant thereof, and cheerfully imagines that the inventor has a sure thing and that everything comes his way.

As matters stand now, the public does not get the benefit of our patent laws; and the law thus misses its highest purpose. Our degenerated rules of practice and procedure simply serve to strengthen the rich and mighty, who apparently disburse the funds for litigation, but in the end make the consumer, the public, pay the bill. But there are many public-spirited lawyers, disregarding narrow-minded professional interests, who have spared no pains to expose this condition of affairs and have urged reforms.

As to the inventor, he is most to blame. I have met few inventors who, when asked for a remedy, did not come out right away with impractical or far-fetched cures. Most of them want to make a radical change in every department of our patent system, forgetting that it is easier to break down than to build up. Others suggest pet remedies of their own, but the worst of all is that no two inventors can agree on the subject. In justice to the inventors, I should mention that most of the lawyers I have met are in the same predicament. In the meantime, the real fact is that very few reforms are necessary in order to remove the absurd conditions of our patent system, and these reforms can easily be accomplished if we can only agree on them. This I shall try to explain:

Formerly, all patent cases, on appeal, went by right, from the lower courts to the Supreme Court of the United States. The latter court not only rendered final decisions, but, what is more important, saw to it that the proper rules of practice and procedure were observed in the lower courts. The Supreme Court acted practically as a supervising body on our patent system, and lent considerable prestige to it, but through the rapidly increasing development of this country, the cases before the Supreme Court became so numerous that finally it took three to four years, after an appeal was filed, before a case could be heard. This amounted practically to a denial of justice, because some of the patents expired before their case was reached.

So, in 1891, a remedy was inflicted which has proved to be much worse than the ailment. Nine Circuit Courts of Appeal were organized, and each court, independently, can give *final* decision in patent cases. This has brought us into an intolerable condition of affairs. Indeed, each Circuit Court of Appeals can adjudicate only for its own circuit, and being independent of control by any other Circuit Court of Appeals, each court makes decisions as it thinks right, based upon the evidence submitted and in accordance with its own view of the law. *So that we have now the absurd condition that some patents are valid in some parts of the country and invalid in others.* Any litigant with much money, who has been beaten in one circuit can carry on his infringements with impunity in an adjacent circuit or drag on new suits forever and a

* Paper presented at a joint meeting of the Am. Soc. Chem., Am. Electrochem. Soc., and the Soc. of Chem. Ind., New York, April 19th, 1912.

day. While doing so, he knows very well that he can postpone a final decision as long as he is willing to pay his lawyers. But this is not the worst of the situation. Since the Supreme Court of the United States is no longer *by right* the final arbitrator in case of appeal, our whole patent sytem has lost the prestige and correcting influence of a final court, that supervises the faithful observance of proper rules of practice and procedure.

I am told that we have some good rules of practice, formulated long ago by the Supreme Court, but that since the practical elimination of this court in patent cases, lawyers and experts, for reasons of their own, have acquired the habit of disregarding these rules or "waiving them by courtesy" for reasons of their own. I am even told that if these rules were honestly adhered to, the testimony of any patent suit could be ready for the court at the end of six months.

A bill for a court of Patent Appeals has been pending now before Congress from year to year, and seems to meet with almost unanimous approval, even from lawyers. The only serious opposition seems to be on the part of some politicians, who do not like the idea of new judgeships being created while their political opponents are in power. If this argument is kept up, the bill will never pass, unless we unite our voices to demand it.

Give us a Court of Patent Appeals which will render final decisions by which we can abide, instead of the absurd condition of affairs where one Circuit Court of Appeals can oppose its decision to that of another. Give us a Court of Patent Appeals which shall formulate and maintain common-sense rules of practice and procedure, and stop the abominable custom of taking unrestricted testimony without a presiding judge. Let us exclude all testimony which has nothing to do with the case, but which is entered as a trick to prolong litigation indefinitely.[1]

Let testimony be taken in open court as it is done in Germany, in England, and by other nations, where cases are tried and settled at relatively small expense and in a short time, instead of taking many, many years, as happens here. In Germany and in England, patent infringements are treated just like any other violation of property rights; with the same severity as though somebody had stolen or damaged another man's property.

While we are about it, let me mention the urgent need of a new patent office building. That awkward Greek temple in F street was acceptable enough when our country was so much smaller. It now has become a conjested, cumbersome, impractical fire-trap in which, some day, all the valuable records of pending and allowed patent cases will be destroyed. Whenever this occurs, and it may happen to-morrow, it will prove a real calamity for those of our manufacturers whose business is dependent on patents. That fire will give unusually unfair opportunties of making money to those who live and thrive on patent litigation.

The patentees of the United States have paid, up to date, to Uncle Sam, about seven million dollars in excess over expenses of the Patent Office. This fund has now accumulated to the credit of the Patent Office. Why should it not be used to construct a well-equipped modern business building, where our patent records, which you and I have paid for, are kept in fireproof rooms? Such a building should be provided with all the equipment necessary for a thorough search. Many important literature references are not available in the Patent Office. It seems incredible, but complete copies of patents issued in some countries like Belgium, France and Canada are lacking. If these lacking records had been available to the examiners, many invalid patents would not have been issued through sheer want of means of obtaining full information as to prior published disclosures. It is truly astonishing that under such handicaps, our overworked patent examiners have been able to furnish so much good work. An up-to-date patent building should possess also a complete laboratory, where simple chemical and physical questions can be demonstrated promptly and easily.

A very desirable reform in the practice of the Patent Office would be the introduction of the German system of public objection to an "allowed" patent, before it is definitely "issued." In Germany, in Austria, and in England, after a patent has been examined and allowed by the examiner, the title and the claims are published and copies of the text can be obtained from the Patent Office. Then, during a period of two or three months, objections to the issue of the patent can be filed in writing by anybody. Copy of the filed objections are forwarded to the applicant, who then has a few months to file an answer. In this way, the examiner has the benefit of a thorough public discussion of the subject before that patent is definitely issued. This involves a delay of several months in the issue of a valid patent, but this is a very small hardship, indeed, if one takes into consideration the fact that a patent issued after severe public contestation gains much in value by its record. Furthermore, this procedure is now successfully used in the U. S. Patent Office for the registration of trade-marks.

Some other useful reforms have been suggested, reducing the needlessly large number of appeals in case of interference.

Our interference rules may appear very logical in accordance with the conception that in the United States, a patent belongs to the first diligent inventor, independently whether he be of the first patent applicant or not, as long as his invention has not been in commercial use before that period. To the uninitiated, this may seem an excellent safeguard to insure that the first inventor should receive the reward of his intellectual work. Unfortunately, any poor inventor, who has been through interference cases, knows that without much money, an interference case becomes almost a hopeless proposition if he has to deal with wealthy antagonists. Indeed, I know of an interference case which has been going on for the last six or seven years, and which has already cost one of the contestants over $60,000. Even after the interference case is decided in one's favor, one has to take all the ordinary chances of further expensive infringement suits. Is this to the benefit of the public, for whom primarily, our laws are created? Let us see: The public wants as early as possible a disclosure of any invention, and with that end in view, the patent law stimulates such disclosures by offering, as reward, seventeen years of patent monopoly. Yet everybody knows that our interference system hopelessly delays the publication of an invention. Furthermore, our interference rules are in many ways a terrifying menace to the industries of the country.

For instance, a man applies for a patent. The patent is allowed and published. On the strength of this patent, a company is formed, which goes ahead, builds an expensive factory, and starts operations. Then, it has frequently happened that an interfering patent application, which was not known to exist at the time the company was organized, embodies identical claims, and is put forward in objection to the published patent. This may invalidate the patent on which the company was formed, and thus stop and annihilate an enterprise which was begun entirely in good faith, and on a sound basis. Such a thing is impossible with the German system, where the first applicant, unless his application is based on fraud or theft, gets the patent, as long as no one else can prove prior use or prior public disclosure. Rigid examination, followed, after allowance, by a short period for public objection, make the German proceedings relatively inexpensive, and give added value and prestige to patents issued under this system.

It may be objected to this system that it induces filing an application before the invention is sufficiently ripe, but even with our system, the same objection holds good. Furthermore, with our current methods, it is possible to file patents and let them pend for many, many years, and use these pending applications as a drag-net in which to catch any other patents which may be applied for by others, and by which to get the benefit of any practical developments or improvements which go on in the meantime; this was clearly demonstrated in the famous Seldon case.

For deciding priority in purely scientific publications, it has been accepted, since the time of Humphry Davy, that "priority of publication, unless in case of fraud, means priority of conception." This simple rule, if applied to the Patent Office system, would sweep away the most complicated and most expensive part of our Patent Office methods. At the same time, it would stop an interpretation of our patent law, which is decidedly dangerous and unfair to the unsuspecting public, and has no advantage to the inventor, unless he be rich, or unless he be propped by wealthy backers.

All these reforms, or improvements, whatever you want to call them, are relatively simple and might have been obtained long ago, if the real interested parties, the public and the inventors, had demanded them. If we unite in our demands we can surely obtain them.

To the honor of the better class of lawyers, let me mention that the Patent Law Association of Washington is doing good work to accomplish some much needed reforms. Lately, in conjunction with the American Institute of Chemical Engineers, and the Inventors' Guild, a start has been made toward awakening the interest of our national engineering societies. Let us all join in this movement. Let us not overlook the fact that our legislators need as much education on this subject as the public at large. But if we try to suggest reforms, let us be practical and first concentrate our efforts on those reforms upon which we can all agree. Let us avoid theorizing or dreaming. A perfect patent law will never exist, except perhaps in heaven, where all men are angels. Then patent laws, as well as other laws, can be dispensed with—but we are still on the earth and for a long time.

Remember that if there is much to criticize in our patent system, there exists the same chaos in our civil and criminal laws, which badly need a general overhauling.

We chemists or engineers are apt to forget that if science, engineering, and all achievements based on exact knowledge and sound reason, have made immense progress in late years, our laws and the administration thereof, have advanced little beyond what they were two or three thousand years ago, so that they are now an anachronism ill adapted to our modern conditions of life. But most judges and lawyers, when they talk about dispensing justice, have acquired, like the Chinese Empire, the habit of looking backwards for "precedents," which for them still remain the most respectable and the most imposing arguments.

Why could this intricate subject of patent reform not be submitted to a competent commission created by the president? This commission, before suggesting or endorsing reforms, should consult with representatives of our national technical and engineering societies, as well as with manufacturers, business men, representatives of the Patent Office and lawyers. A resolution to that effect has recently been addressed to the President of the United States by the Inventors' Guild.

[1] Judge Hough, in giving his opinion in the famous Seldon case, where 36 huge volumes of printed testimony were submitted, took occasion to denounce our absurd methods of patent litigation, as follows:

"It is a duty not to let pass this opportunity of protesting against the methods of taking and printing testimony in equity, current in this circuit (and probably others), excused if not justified by the rules of the Supreme Court, especially to be found in patent cases, and flagrantly exemplified in this litigation. As long as the bar prefers to adduce evidence by written deposition, rather than *viva voce*, before an authoritative judicial officer, I fear antiquated rules will remain unchanged and expensive prolixity remain the best known characteristic of equity.

"*But reforms sometimes begin with the contemplation of horrible examples*, and it is, therefore, noted that the records in these cases, as printed, bound and submitted, comprise 36 large octavo volumes, of which more than one-half contain only repeated matter, i. e., identical depositions with changed captions and exhibits offered in more than one case. In reading the testimony of one side in one set of cases there were counted over 100 printed pages recording squabbles (not unaccompanied with apparent personal rancor) concerning adjournments—and after arriving at this number it seemed unnecessary to count further. In many parts of the record there are not five consecutive pages of testimony to be found without encountering objections stated at outrageous length, which may serve to annoy and disconcert the witness, but are not of enough vitality to merit discussion in 2,000 pages of briefs. Naturally tempers give way under such ill-arranged procedure, and this record contains language, uncalled for and unjustifiable, from the retort discourteous to the lie direct. All this lumbers up the court room, *while clients pay for it*.

"Even when the evidence in equity was taken up by written answers to carefully drawn interrogatories, the practice was not marked by economy or celerity, but stenography and typewriting, the phonograph and linotype, have become common since our rules were framed, have made compression and brevity old-fashioned, increased expense, and often swamped bench and bar alike by the quantity rather than the quality of material offered for consideration.

"Motions to expunge and limit cross-examination should have been made in these cases, though they are feeble remedies exposing counsel to personal reproach, and rendering judges afraid of keeping out of evidence what they cannot (on motion at all events) understand. *But the radical difficulty of which this case is a striking (though not singular) example will remain as long as testimony is taken without any authoritative judicial officer present and responsible for the maintenance of discipline and the reception or exclusion of testimony.*"

Four Hundredth Anniversary of Mercator's Birthday

THE fifth of March this year was the four hundredth anniversary of the birth of a man whose name is known to practically every school boy who has learned to handle a geographical atlas. We are all familiar with the Mercator projection of the world's map, a projection which has the disadvantage of exaggerating distances measured along a given parallel in the higher latitudes but which offers certain other advantages. Such a projection is produced by representing the meridians as straight lines and exaggerating the scale along each meridian at every point in the same proportion as that along the corresponding parallel.

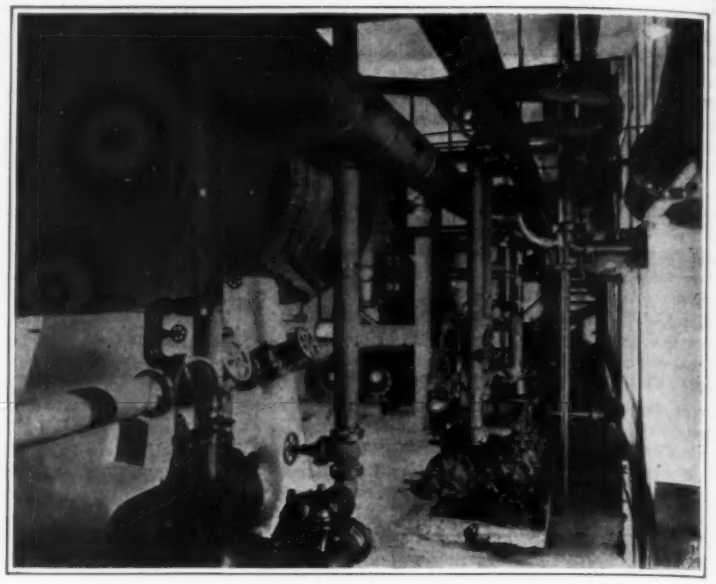
Mercator was born of German parents in 1512 in the small Belgian town of Rupelmonde. The greater part of his life, however, was spent in Germany, at Duisburg, where he also died on December 2nd, 1594. It is probably not very generally known that the word "atlas" as used to denote a collection of geographical maps is due to Mercator.

Warm Water for Indoor Plants

WE read in *Cosmos* that cuttings of certain plants can be made to bloom in winter by placing them in a vase of water kept at 40 deg. Cent. Thus, for instance, syringas can be made to bloom luxuriantly in about a fortnight's time, even if there were no buds observable when first cut. The only difficulty is to maintain the water at the proper temperature. This, however, is not unsurmountable in an apartment during the winter months from November to February. All that is necessary is to keep the plants in a room heated at a steady temperature, and to pour into the vase water a little over 40 deg. Cent. (104 deg. Fahr.) four or five times a day, particularly in the morning and toward evening.

To Bleach Straw (according to Kurrer).—Pour boiling water over the straw, allow it to stand for 24 hours, and repeat this operation several times until the water is only faintly tinged. Then follow three hot over-pourings, each allowed to stand for 24 hours and each consisting of 100 parts of water and 24, 16, and 12 parts of soda, respectively. Rinsing with boiling water follows, a bath of chlorine, a bath of sulphurous acid, and a washing out. By this treatment, the straw is rendered perfectly white, and remains completely pliant and flexible.

The Boiler Room ShowingMechanical Coal Feeders.



The Heaters and Pumps of the Hot Water System.

Steam Turbo-Generator Station

With Hot Water Heat Distributing Plant

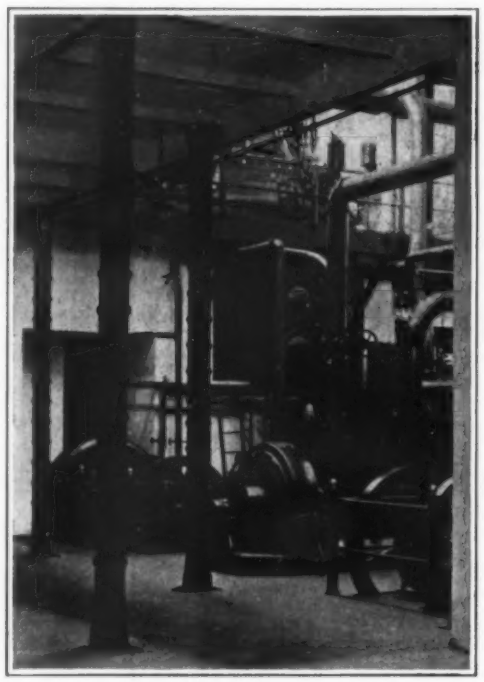
AN interesting feature of the steam turbine driven electric station at Atlantic City, N. J., illustrated by the accompanying photographs, is that it carries a hot water heating load for a large portion of the year which therefore has to be considered in connection with the efficiency of the electric station as a whole.

Recently both the electric light and power load and the hot water heating load of this station had increased to such an extent that it was necessary to provide additional boiler, steam turbine and electric generator capacity.

A thoroughly up-to-date steam turbine driven station was therefore decided upon for supplying both electricity and hot water heat by the Atlantic City Electric Company, and we are indebted to General Manager L. W. Byers for the accompanying illustrations and data in reference to the electric equipment and the facilities for handling and storing the coal as well as the steam extracted from the second and third stages of turbines, which is used for heating service.

The station comprises six water tube boilers of the Babcock & Wilcox type operating at a pressure of 225 pounds per square inch and equipped with single loop superheaters within the boiler settings. There are two 54 horse-power Curtis turbines used for driving centrifugal pumps supplying feed water to the boilers, these rotary pumps being of the three-inch four-stage horizontal type.

The coal is chuted from the fuel bunkers overhead to six Taylor gravity stokers fitted to the furnace of the boiler. There is a motor operated from trolley wires attached to the runway girder and a coal crusher mounted on a truck designed to run on a track over the roof of the boiler house. This equipment has a steel plate hopper on the top of the crusher capable of holding two grab buckets full, the crusher being so designed that when it is handling fine coal this fuel will pass directly through the crusher without the crusher electric motor being required,



View in the Basement Showing Auxiliaries and Turbo Foundations.

this motor being so arranged that it can be cut out from the gears and employed to run the truck with the crusher in either direction along the track over the coal bunkers.

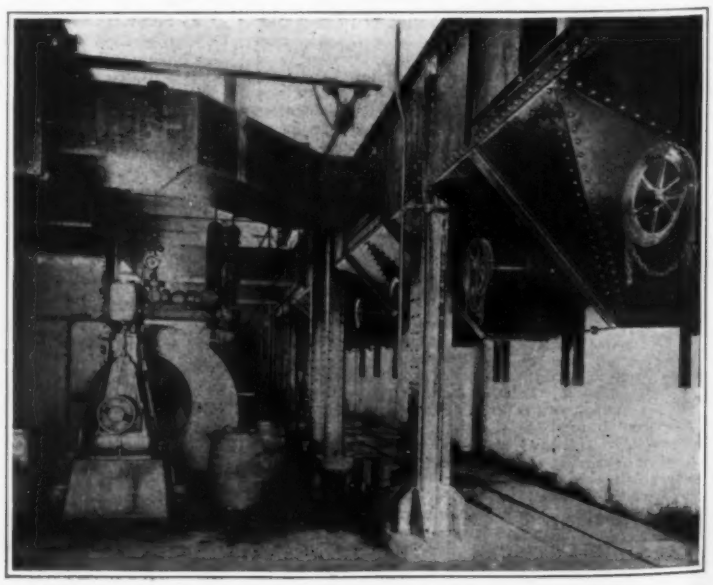
There are four electric motors on the crane which has a span of 100 feet and is equipped with a two-yard grab bucket together with the coal crusher which is designed to pass the fuel through 1½-inch mesh at the rate of 75 tons an hour if desired. This electric crane has one motor for the bridge travel and one motor for trolley travel while two other electric motors are provided on separate drums fitted with friction clutches for operating the raising, lowering, opening and closing motions. This electric crane has a capacity of handling 60 tons of coal per hour from the cars to the storage pile and 40 tons of fuel per hour to the coal bunkers from the cars. The main hoist has a speed when fully loaded of 120 feet per minute, the trolley having the same speed, while the crane itself is operated at 300 feet per minute.

Direct current motors of the 250-volt inner pole type are used, the smallest for trolley travel having a capacity of 5 horse-power, while two 30 horse-power motors are used for the bridge travel and auxiliary hoist, the main hoist motor having an output of 50 horse-power. The attendant riding with the trolley controls all the movements from the cage, the auxiliary hoist motor being used for closing the two-yard grab bucket. Under the craneway outside the electric station there is a storage space for 15,000 tons of coal, which may be brought to the station by coal barges at the dock in front of the power-house or by trains of cars over a siding from the Pennsylvania Railroad.

The steam turbines are installed 16 feet above the floor level of the station while the condenser intake tunnel is located 12 feet below the mean low water level in the concrete foundation extending from the bottom of the tunnel to the turbine. The discharge tunnels and intake tunnels measure 4 feet in height, the latter being constructed above the former.

At high tide the maximum lift to the basement is 6 feet, and 10 feet at low water. The intake extending 130 feet from the station is protected by a crib of reinforced concrete, beams being used for tying the walls and brac-

In the Turbo-generator Room.



Ash Hoppers and Blowers in the Basement.

ing the structures. Two 42-inch sluice gates are provided in the front wall of the intake crib and cast iron guides are used for screens and grilles.

The turbo-generator installation consists of two units of 2,000 kilowatts each and one 4,000 kilowatt turbo-generator, all of which supply a three-phase current of 2,300 volts pressure and a frequency of 60 cycles per second.

For the 2,000-kilowatt steam turbine two boilers each are provided with a 6-inch outlet feeding into an 8-inch header passing to the turbine throttle through the division wall, while the steam is supplied to the 4,000 kilowatt unit by a 10-inch header.

The steam headers are connected with loops, the latter being of 6-inch pipe between the first and second units and of 8-inch pipe between the second and third units, each header being fitted with a valve.

From the 4,000 kilowatt unit there is a 34-inch free exhaust while from the two 2,000-kilowatt steam turbines a 16-inch free exhaust is connected to the condenser. From the 4,000-kilowatt unit there is an 18-inch outlet and a 16-inch outlet from the second stage of each of the 2,000-kilowatt turbines, while a 14-inch connection has been installed running from each outlet to the 14-inch exhaust header.

The second stage connection from each turbine has an 8-inch back pressure valve serving as a relief together with a 14-inch gate and a 14-inch automatic reverse current valve.

For the hot water supply system the connections to the headers include 14-inch gate valves and 14-inch oil separators. A surface having 6,000 square feet of condensing area is included in the auxiliary equipment of the 2,000-kilowatt turbine, together with a priming pump and a 3-inch turbine-driven hot well pump, a dry vacuum pump and a 16-inch volute circulating pump.

The 4,000-kilowatt steam turbine has a surface condenser of 10,000 square feet condensing surface and a similar pumping equipment, which however includes a 20-inch circulating pump and a 4-inch turbine-driven hot well pump.

All of the auxiliary equipment is located in the basement including the feed water heater, hot water circulating pump, stoker and fan engine and other apparatus together with the 100-kilowatt engine-driven exciter set, the oil compressor, oil pumps and filters.

The stack at this station measures 216 feet in height with an inside diameter of 13 feet and is constructed of brick and concrete, the former being used in the base. These steam turbines are so installed that steam may be taken from the second and third stages and an 18-inch opening is therefore provided in each of these stages while the second stage has hand operated valves by means of which the nozzle opening may be controlled to the third stage.

Between each turbine and the control board there is a signal system provided. An annunciator drop signal equipment is also employed for indicating when the relays on the oil switches and circuit breakers are open. This is undoubtedly one of the most complete stations in the United States for the class of service for which it is intended.

The hot water heating system covers an area of about one and a half miles extending from New Jersey Avenue to Arkansas Avenue and from the board walk to Baltic Avenue. For taking care of this hot water heating load there is a 14-inch main passing underground from the new steam turbine electric station. This new plant is one of the attractions of Atlantic City, and supplies current for incandescent lighting from the three-phase alternating current generator, while arc machines and direct current dynamos are driven by synchronous motors at the same power station. As will be seen, the plant presents some features of special interest, which render it well worthy of note.

A Gasoline Engine With Auto-Ignition*

A Remarkable Lightweight Internal Combustion Motor for Automobiles and Aeroplanes

By A. M. Low

IT is not a very easy thing to describe any really new engine, for everyone at once pictures some slight alteration in valve gear, an extra net construction, or other *detail* alteration.

This engine is absolutely different from any other, though its method of working is not unlike the Diesel. In this comparison, however, there are two vital exceptions, namely, waste heat is utilized, and no pumping gear has to be worked by the engine itself. The principle upon which the "Low" engine is based is the utilization of *waste* heat, and is identical with that of the coal engine, which was described in the technical press about a year ago, and which further tests have shown successful.

The best way to understand this engine is to imagine an ordinary car engine with a very high compression, and with the water-jacket full of gasoline. The engine is first run in the ordinary manner, the liquid gasoline being sucked through a valve in the head. As soon as the engine gets hot, the compression is increased to its full amount by fully dropping the exhaust valve, and the jacket has by this time become full of gasoline vapor under a high pressure.

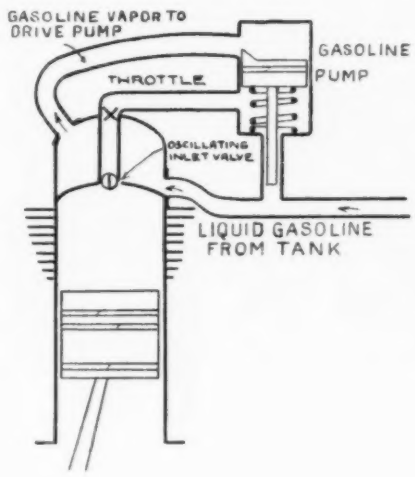
On the suction stroke the piston draws pure air into the cylinder, which is compressed to above 500 pounds per square inch. At the top of the stroke the gasoline vapor is admitted, thus causing the "explosion." The burnt gas is exhausted in the ordinary way.

Having once indicated the method of working, it will be obvious that there are several ways of carrying it into effect. The engine which has been successfully run was fitted, for the sake of simplicity, to a small Duocar. Its bore and stroke were 2 inches and 4 inches, respectively, the engine being built after the manner of an ordinary 60-degree twin. Each cylinder is jacketed throughout its length and cooling fins are fitted on the outside. This arrangement was adopted, as it was thought necessary to have a considerable volume of gasoline vapor available. In the top of the head is a trip valve held down by a spring; this valve can be altered as regards the periods of its opening by varying the stiffness of the spring from the outside. It is fed by a coil of steel tubing, which is screwed to its seating after the manner of an automatic inlet-valve pipe. The other end of the steel coil is connected to the *exhaust* of a pump that is worked by the pressure of evaporated gasoline. The pump is used to deliver liquid gasoline from the tank to the jacket, where it is vaporized, and then passes via the pump through the steel tubing into the cylinder, by the trip valve as indicated.

It needs no knowledge to see that this arrangement is a bad one, but it was done in the first engine, as it was thought necessary that the gasoline should enter the cylinder quickly and also because of the extreme difficulty of making any gland to stand gasoline vapor under high compression. Gasoline vapor will even leak through ordinary cast iron unless the grain is particularly close.

Once the engine warms up no ignition is necessary, but it has been found that if proper combustion is to be obtained without the use of a spark, the gasoline must enter the cylinder quickly. Now, the great object is to get an engine which runs smoothly, and this can only be accomplished by admitting the gasoline gradually so as to maintain the pressure during most of the stroke. To allow for this an ordinary sparking plug is used close to the point where the gasoline vapor enters, and the spark is allowed to take place during the whole of the firing stroke.

It is interesting to note that, whereas at ordinary pressures the old theory of stratification has been found to me mainly false—where the pressures are in the neighborhood of 300 pounds per square inch and over the effect is very noticeable, and it is this that causes the gasoline to burn more or less locally in the compressed air as it is injected, giving a slow, steady rise of "explosion" pressure.



On this experimental engine timing is obtained by varying the depth of the trip-valve plunger. This has been found a quite unnecessary arrangement, but for an engine that has to run at one speed it is satisfactory, as is proved by the fact that while it renders an engine very untractable it has been possible to obtain 18 horse-power at 3,400 revolutions per minute from this little engine, with a cubic capacity of less than 400 cubic centimeters.

Naturally, it is not possible to give very complete details of the valve and its arrangement, or of the special gasoline pump used, as these will form the matter of separate patents. The future design of this engine is not without interest. It is *not* desirable to jacket the whole of the cylinder; we are, of course, speaking of air-cooled engines, though the principle applies exactly the same to water cooling; and in future engines, which are to be built for the purpose of developing this system, the head only will be jacketed, keeping it cool, and providing ample evaporating service. The gasoline vapor will be admitted to the cylinder by means of an oscillating inlet valve, and the moment of ignition will be variable, just as the spark in an ordinary engine, the place of the throttle being taken by controlling the exhaust of the vapor pump.

It must be emphasized that this pump is only being used as a convenient control, and for getting the liquid gasoline into the *jacket*. In the present engine the trip valve has been found to be quite reliable, but it makes the engine difficult to control except by lifting the exhaust, as the engine, of course, runs synchronously with the gasoline pump, which vibrates up and down very much in the manner of a Worthington pump.

There is no need to go into a longer description of the present engine, but it is interesting to see what are its possibilities. This little engine of the cubic centimeter ordinarily fitted to a light-weight motor bicycle has been reduced to a fuel consumption of 0.46 pints per brake horse-power hour, and this with a valve gear which is extremely inefficient. It develops 18 horse-power as nearly as possible at 3,400 revolutions, it does not run with great vibration, and no special precautions were taken with its construction. It must be admitted that several slight accidents took place, as was only to be expected during any experimental work. The great point which has to be remembered is that the engine works well, and that it is not merely a much talked of design on paper.

For motor cycles a small twin with a bore and stroke of, perhaps, one or two inches respectively, should be sufficiently powerful for ordinary purposes. Cars could be built with enormously powerful engines using no more gasoline than the ordinary car of to-day, while for commercial work the value of such fuel economy can hardly be over estimated. Owing to the method of causing the explosion, the average pressure can be maintained during the greater part of the stroke, as the gasoline is injected for about 50 per cent of the power stroke, which makes the engine develop its power at very low speeds.

The Duocar to which it is at present fitted has taken two heavy passengers up a gradient of about 1 in 18 at 40 miles per hour with the engine turning at between 1,500 and 1,600 revolutions per minute, which will give an idea of the great possibilities of the engine, as with a properly constructed valve gear and a properly controlled and timed admission the car can be driven almost like a steam car, and it can be started up by merely warming the jacket with a small spirit lamp.

The revolutionary advantages of this system need no exaggeration, but it has been a little amusing to receive so many orders from people who do not seem to realize that new inventions are not developed in a day, and it will probably be quite a year before this system can be entrusted to the general public.

One of the applications which brings out this system more than any other has already been noticed by the war office authorities, who foresee possibilities of its adaptation to aeroplanes. Engines built in this way would be very light for the power developed, the evaporation of gasoline helps to keep them cool, their fuel consumption is low, and owing to the expansive nature that it is possible to give to the explosion they should prove effective in reducing propeller flutter. It would enable aeroplanes to be constructed very substantially without reducing their lifting power, and once that is understood there is but little more to say.

There seems to be every reason for looking forward hopefully for further developments.

* Reproduced from *The Automotor Journal*.

The Influence of Ozone in Ventilation

Its Principal Function Seems to be that of a Deodorizer

By Leonard Hill, M.B., F.R.S., and Martin Flack, M.A., M.B., B.Ch.

THE good effects which result from efficient ventilation and open-air treatment are generally supposed to be due to the chemical purity of the air. They are due really to the movement, coolness, relative humidity of the air, and to the ceaseless variation of these qualities. The ventilating engineer has hitherto followed a great illusion in thinking that the main object to be attained is chemical purity of the air. The heating engineer has sought after an equally great illusion in striving to give us a uniform summer temperature (Pembrey). The ventilating and heating engineers primarily should aim at giving us air which is cool, of proper relative humidity, and which moves so as to vary the cutaneous state of the body. Our comfort and discomfort in crowded rooms and shut-up places depend, not on the chemjcal purity of the air, but, to a minor degree, on the influence of the smell of the air on the olfactory sense, and, to a vast degree, on the influence of the temperature, relative humidity, and the variation of these qualities of the air, which act on the great field of cutaneous sensibility.

It is needless to point out that our sense of well-being depends to a very great degree on the comfortable condition of our skin, and yet the ventilating and heating engineers have paid little attention to this. While asserting that the chemical purity is of no account, we make the proviso that the air is only altered by the presence of human beings, and is neither rendered poisonous by the escape of coal gas, or other noxious trade product, nor deoxygenated by the oxidative processes of the soil, as it is in mines. We are speaking of the discomfort and ill-health caused by the deficient ventilation of, or bad methods of heating, dwelling-houses, schools, factories, theaters, chapels, etc.

The chemical purity of the air can be considered from three points of view, the concentration of CO_2, the concentration of O_2, the supposed presence of organic poison exhaled in the breath.

Owing to the fact that a percentage of CO_2 is not legally permissible in factories which exceeds a very few parts per thousand, it is commonly supposed that any greater excess of CO_2 acts as a poison.

The truth of the matter is quite otherwise; for, whatever the percentage of CO_2 in the atmosphere may be, that in the pulmonary air is kept constant at about 5 per cent of an atmosphere by the action of the respiratory center. It is the concentration of CO_2 which rules the respiratory center, and to such purpose as to keep the concentration both in the lungs and in the blood uniformly about the same. This fact, which was first firmly established by Dr. John Haldane, is of fundamental importance.

It is impossible that any excess of CO_2 should enter into our bodies when we breathe the air of the worst-ventilated room in which the percentage of CO_2 assuredly does not rise above 0.5 per cent, or at the outside 1 per cent. The only result from breathing such an excess of CO_2 is a slight and unnoticeable increase in the ventilation of the lungs. The increased ventilation is exactly adjusted so as to keep the concentration of CO_2 in the lungs at the normal 5 per cent of an atmosphere. The very same thing happens when we take gentle exercise, and produce more CO_2 in our bodies; the pulmonary ventilation is then slightly increased, and thus the CO_2 concentration in the blood and lungs is kept at the same uniform level. At each breath we rebreathe into our lungs the air in the nose and large air-tubes (the dead space air) and about one-third of the air which is inhaled into the lungs is "dead space" air. Thus, no man breathes in pure outside air into his lungs, but air contaminated perhaps by one-third, or (on deep breathing) by one-tenth with expired air. When a child goes to sleep with its head partly buried under the bed-clothes, and in a cradle with the air confined by curtains, he rebreathes the expired air to a still greater extent, and so with all animals that snuggle together for warmth's sake. Not only the new-born babe sleeping against its mother's breast, but pigs in a stye, young rabbits, rats and mice clustered together in their nests, young chicks under the brooding hen, all alike breathe a far higher percentage than that allowed in our factories by the officials of the Home Office. To rebreathe one's own breath is a natural and inevitable performance, and to breathe some of the air exhaled by another is the common lot of men who, like animals, have to crowd together and husband their heat in fighting the inclemency of the temperate and Arctic zones. By a series of observations made on rats confined in cages with small ill-ventilated sleeping chambers, we have found that the temperature and humidity of the air —not the carbonic acid and oxygen concentration of the air—determine whether the animals stay inside the sleeping-room or come outside. When the air is cold, they like to stay inside, even when the carbonic acid rises to 4 or 5 per cent of an atmosphere. When the sleeping chamber is made too hot and moist they come outside.

In breweries the men who tend the fermentation vats work for long hours in concentration of CO_2 of 0.5 to 1.5 per cent. ¼(Lehmann.) Such men are no less healthy and long-lived than those engaged in other processes of the brewing trade. In the Albion Brewery we analyzed on three different days the air of the room where the carbonic acid gas, generated in the vats, is compressed and bottled as liquid carbonic acid. We found 0.4 per cent to over 1 per cent of carbonic acid in the atmosphere of that room. The men engaged therein worked twelve-hour shifts, having their meals in the room. They had followed this employment for eighteen years, and without detriment to their health. It is only when we come to the higher concentrations of CO_2, such as 3 per cent to 4 per cent of an atmosphere, that the respiration is increased so that it is noticeable to the individual himself, and such percentages, of course, diminish the power to do work; for the excess of CO_2 produced by the work adds its effect to the excess in the air, and the limit of panting is soon reached. Thus the power to work is checked. Divers who work in diving dresses, and men who work in compressed-air caissons, constantly work in concentrations of CO_2 higher than 1 per cent of an atmosphere, and so long as the CO_2 is kept below 2 per cent to 3 per cent of an atmosphere, they are capable of carrying out efficient work.

It results, then, from what we have said, that concentrations of CO_2, such as occur in the most crowded and worst-ventilated rooms, are of no account. Forced to admit this fact, the hygienist has fallen back on the hypothesis that organic chemical poisons are exhaled in the breath, and that the percentage of CO_2 is a valuable guide as to the concentration of these. It is necessary, he says, to keep the CO_2 below 0.1 per thousand, so that the organic poisons may not collect to a harmful extent.

Before we turn to the discussion concerning the supposed existence of these organic chemical poisons, we will deal with the question of oxygen. The oxygen in the worst-ventilated schoolroom, chapel, or theater, is never lessened by more than 1 per cent of an atmosphere. The ventilation through chink and cranny, chimney, door and window, and the porous brick wall, suffices to prevent a greater diminution of the oxygen concentration. Now, in all the noted health resorts of the Swiss mountains, such as St. Moritz, the concentration of oxygen is lessened considerably more than this. On the high plateau of the Andes there are great cities: Potosi, with 100,000 inhabitants, is at 4,165 meters (barometric pressure about 450 millimeters Hg.); railways and mines have been built even at altitudes of 14,000 to 15,000 feet. Owing to the nature of the chemical combination of oxygen with hæmoglobin, man can adjust himself to very great variations in oxygen concentration. At Potosi girls dance half the night, and toreadors display their skill in the bull-ring. We have watched our students, shut in an air-tight chamber, until they came to breathe air containing only about 16 per cent of oxygen and 3½ per cent of carbonic acid, and seen their puzzled look when they found they were unable to light a match and smoke a cigarette. There was then too low a percentage of oxygen to support combustion, but of this they were quite unaware. All the evidence goes to show that it is only when oxygen is lowered below a pressure of 14 per cent to 15 per cent of an atmosphere, that signs of oxygen want arise. A diminution of 1 per cent of an atmosphere has not the slightest effect on our health or comfort.

We must now discuss the evidence for the existence of organic chemical poison in the exhaled breath. The evil smell of crowded rooms is accepted by most as unequivocal evidence of the existence of such. This smell, however, is only sensed by, and excites disgust in, one who comes to it from the outside air. He who is inside and helps to make the "fugg" is both wholly unaware of, and unaffected by, it. Fluegge points out, with justice, that while we naturally avoid any smell that excites disgust and puts us off our appetite, yet the offensive quality of the smell does not prove its poisonous nature. For the smell of the trade or food of one man may be horrible and loathsome to another not used to such. The sight of a slaughterer and the smell of dead meat may be loathly to the sensitive poet, but the slaughterer is none the less healthy. The clang and jar of an engineer's workshop may be unendurable to a highly-strung artist or author, but the artificers miss the stoppage of the noisy clatter. The stench of glue-works, fried-fish shops, soap and bone manure works, middens, sewers, become as nothing to those engaged in such, and the lives of the workers are in no wise shortened by the stench they endure. The nose ceases to respond to the uniformity of the impulse, and the stench clearly does not betoken in any of these cases the existence of a chemical organic poison. On descending into a sewer, after the first ten minutes, the nose ceases to smell the stench; the air therein is usually found to be far freer from bacteria than the air in a schoolroom or tenement (Haldane.)

If we turn to foodstuffs, we recognize that the smell of alcohol and of Stilton or Camembert cheese is horrible to a child or dog, while the smell of putrid fish—the meal of the Siberian native—excites no less disgust in an epicure, who welcomes the cheese. Among the hardiest and healthiest of men are the North Sea fishermen, who sleep in the cabins of trawlers reeking with fish and oil, and for the sake of warmth shut themselves up until the lamp may go out from want of oxygen. The stench of such surroundings may effectually put the sensitive, untrained brain-worker off his appetite, but the robust health of the fisherman proves that this effect is nervous in origin, and not due to a chemical organic poison in the air. The supposed existence of organic chemical poison in the expired air is based upon experiments of Brown-Sequard and d'Arsonval. They injected into guinea-pigs and rabbits either the condensation water obtained from the breath, or water which they used several times over to wash out the trachea of dogs. The water was injected subcutaneously and in large amounts, and produced in their hands signs of illness, collapse and death.

These experiments have been repeated by many others, and with negative results by those whose methods of work demand most respect—Dastre and Loye, Van Hofmann Wellenhof, Lehmann and Jessen, Haldane and Smith, Weir Mitchell and Borgey, etc. A few confirmatory results have been obtained by methods of experiment which are truly absurd in their conception. One to two cubic centimeters of condensation water (obtained by breathing through a cooled flask) have been injected into a mouse weighing 13 grammes or so. This is equivalent to injecting 5 liters of water into a man weighing 65 kilogrammes. Who would not be made ill by the injection of about nine pints of cold water beneath his skin? It has been shown that injections of pure water alone in doses of over one cubic centimeter may make a mouse ill. (Inaha.) Such experiments are ridiculous, and deserve not a moment's attention.

In the case of Brown-Sequard's and d'Arsonval's experiments they injected from 4 to 44 cubic centimeters into guinea-pigs and rabbits, either directly into the circulation or subcutaneously. Using the washings of a dog's trachea, or the condensation fluid obtained from the breath, they could not fail to inject traces of the proteins of the saliva. A second injection of such into the same animal might produce the well-known anaphylactic shock. By subcutaneous injection of a foreign protein an animal becomes sensitized, and may be poisoned by a subsequent injection of the same. The sensitivity may be produced by extraordinary small doses—e. g., one millionth of 1 c.c. of serum. Anaphylaxis is never produced by the injection of protein taken from the same species of animal, nor can it be produced by eating foreign protein. There is no reason to suppose that it can be produced by breathing into the lungs traces of a foreign protein. Quite recently Rosenau and Amos have published experiments which seem to show that guinea-pigs can be sensitized by the injection of the condensation water of human breath, so that anaphylaxis is produced in these pigs by a subsequent injection of a trace of human serum. These observers breathed for six to ten hours through a glass tube fitted with a plug of glass wool. Owing to the method employed it seems certain that saliva must have wetted the glass wool, and, carried on in "droplet" form, contaminated the condensation water. Breathing through a tube leads to an expulsion of saliva which does not occur in natural breathing. The guinea-pigs, as we might expect, therefore became sensitized to human protein by the injection of the condensation water containing traces of salivary protein. The authors, however, do not take this view, and think that their results afford evidence in favor of the exhalation of a volatile protein—an organic chemical poison. We cannot admit this view. The question before us is—Do men breathe out a substance poisonous to man? If there were anything in the claims of the American authors, we should expect to find rats, which dwell in the same confined cage and breathe each others' breath, sensitive to the injection of a trace of each others' protein. We are informed, by those who study the phenomena of anaphylaxis, that no such sensitivity can be shown.

After studying the literature on this subject we are convinced that there is no positive evidence which demonstrates the poisonous nature of the condensation water obtained from the breath. We go further and say there is at present no trustworthy evidence of the exist-

ence of any such poison in the exhaled air. Brown-Sequard sought to substantiate his views by carrying out a different series of experiments. He arranged rabbits in a series of chambers, and led the air from one chamber to another, so that each succeeding chamber received the vitiated air from the one before it. In the end cage rabbits died, but if the air received into this cage were passed through sulphuric acid, the rabbits remained alive.

These experiments have been repeated with the greatest care by Haldane and Lorrain Smith; also by Beu, Rauer, Lübbert and Peters, Billings, Weir Mitchell and Borgey, Formanek, etc. It has been proved conclusively that no harm results so long as a sufficient air current is maintained to keep the carbonic acid below a poisonous amount. The animal in the last cage dies when the CO_2 reaches 10 to 12 per cent. If the CO_2 is kept down the animal in the last cage puts on weight and thrives as well as the animal in the first cage. Of course, it is necessary in such experiments to clean the chambers daily, and supply the animals with suitable food and bedding. We have repeated the experiments, in one case leading the air from a chamber containing three rats through a chamber containing a guinea-pig, and in another case leading the air from a chamber holding three rats through another chamber also holding three rats. The chambers were daily cleaned and fresh dry hay and food were put within. The guinea-pig lived in an atmosphere containing about 3½ per cent of carbonic acid, and put on nearly 100 grammes in weight in three weeks, in this respect doing quite as well as another half-grown guinea-pig kept under normal conditions. The rats in the other second chamber did no less well. Thus the evidence obtained from this kind of experiment as to the existence of a poison in expired air is wholly negative. Brown-Sequard's result must be ascribed to suffocation arising from failure in experimental method. We accidentally lost four of our animals from suffocation after the experiment had continued for a month, owing to the chinking of a tube and consequent interruption of the air current. Benedict has shown that a man can live many days in a closed chamber in comfort without damage to his health, having not the slightest cognizance of any defect in ventilation, when the ventilation is so reduced that the carbonic acid accumulates in the chamber up to 1 per cent—that is to say, so long as the air in the chamber is kept cool and dry. We have inclosed eight students in a small chamber holding about three cubic meters of air and kept them therein until the CO_2 reached 3 per cent to 4 per cent, and the oxygen had fallen to 17 or 16 per cent. The wet-bulb temperature rose meanwhile to about 85 deg. Fahr., the dry-bulb a degree or two higher. The discomfort was very great, but this was relieved to an astonishing extent by putting on electric fans placed in the roof, whirling the air in the chamber, and so cooling the bodies of the students.

In a crowded room the air confined between the bodies and clothes of the people is almost warmed up to body temperature and saturated with moisture, so that cooling of the body by radiation, convection by evaporation, becomes almost impossible. This leads to sweating, wetness and flushing of the skin, and a rise of skin temperature. The blood is sent to the skin and stagnates there instead of passing in ample volume through the brain and viscera. Hence arise the feelings of discomfort and fatigue. The fans in our chamber whirled away the blanket of stationary wet air round their bodies, and brought to the students the somewhat cooler and drier air in the rest of the chamber, and so relieved the heat stagnation from which they suffered. The relief became far greater when we allowed cold water to circulate through a radiator placed in the chamber, and so cooled the air of the chamber about 10 deg. Fahr.

Messrs. R. A. Rowlands and H. B. Walker have carried out, with us, numerous experiments in this chamber. They have performed measured amounts of work (raising a weight) under varying conditions of temperature moisture, and with varying percentages of O_2 and CO_2 in the chamber.

As a measure of the exhausting effect of the work, we have counted the frequency of the heart-beat in the first, second and third minute after the completion of the work. When the work is done without over-fatigue the frequency of the pulse, which is accelerated by work, quickly returns to normal. Our results show that increased percentages of CO_2, and diminished oxygen percentages of 2 per cent to 3 per cent and even 4 per cent to 5 per cent, have little effect in modifying the frequency of the pulse, while the temperature and humidity of the air have a profound effect. The feelings of discomfort depend on the excessive heat and humidity, and are relieved by cooling and whirling the air in the chamber. If we suddenly raised the percentage of CO_2 in the chamber up to 2 per cent we found the subjects inside were quite unaware of this. If we sat outside and breathed through a tube the air in the chamber we felt none of the discomfort which was being experienced by those shut up inside. Similarly, if one of those in the chamber breathed through a tube the pure air outside he was not relieved. Similar experiments were carried out by Paul, and with like results. The cause of the discomfort is thus proved to be due to the excessive heat and humidity, and absence of movement of the air. Studying the ventilation of sleeping-cars, T. R. Crowder finds that in these cars, called "close" or "stuffy," the temperature invariably is high. There has sometimes been an unpleasant odor. A high temperature renders this more noticeable. The most marked offensiveness noticed was in a day coach, where "the air was of such a degree of chemical purity as to indicate ideal ventilation by any standard that has ever been proposed. The car was hot and had many filthy people in it." Perfect comfort has been found associated with the highest chemical impurity in other cars.

After healthy and clean students have been shut in our chamber we find there is no offensive smell in the confined air.

Ventilation cannot get rid of the source of a smell, while it may easily distribute the evil smell through a house.

As Pettenkofer says, if there is a dungheap in a room, it must be removed. It is no good trying to blow away the smell. Houses and people and their clothes and bodies must be made clean, and latrines and kitchens placed on the top of houses, or outside them, and on the windward side. There is yet another aspect of ventilation which we have not yet discussed, viz., bacterial infection. Catarrhal infections are spread by the expulsion of droplets of saliva when speaking, coughing or sneezing. During quiet respiration the exhaled breath is practically sterile, for the wet mucous surfaces of the respiratory tract catch all the inhaled bacteria, and no "droplets" are exhaled. Can we lessen the "droplet" infection by ventilation? Fluegge concludes, from the results of his admirably contrived experiments, that we cannot. He says a current sufficient to drive out such droplets cannot be borne by the inhabitants of the room. A moderate ventilation current tends to keep the droplets suspended in the air. In a still room they soon fall to the ground, and, clinging to floor and furniture, may be wiped up next morning and removed by the housemaid.

We cannot hope to prevent infection in crowded railway carriages, theaters, chapels, schools, etc. The epidemics of common colds that sweep through the community show this only too well.

It is impracticable to isolate all those suffering from colds, but we can teach them at least to cough and sneeze into a handkerchief, and perhaps even talk with a handkerchief in front of their mouths. Above all, we must seek to keep up our immunity and resist infection. Immunity depends on the quality and flow of the blood, the supply of immunizing substances in the tissue lymph, the activity of the ciliated epithelium and phagocytes which form a second line of defense against bacteria. The state of all these defensive mechanisms of the respiratory membranes are modified by the temperature and relative humidity of the air. Exposure to over-heated dry air dries up not only the skin but the membranes of the nose and throat, and so lessens immunity.

Exposure to over-heated moist air brings the blood into the skin, lessens the circulation through the viscera, and deprives us of the stimulating effect of cold on the cutaneous nerves, decreases the evaporation from the respiratory tract, diminishes the muscular activity, and so the amount of oxygen breathed in and food eaten, and thus altogether lowers the plane of our existence. Hence arise diminished health, strength, and increased susceptibility to catarrh. Those who habitually expose themselves to cold rarely take cold.

Confinement in over-heated, windless air, which too often pervades places of business and amusement, is one of the chief causes of the depressed physical and mental vigor of town dwellers. The evidence of daily life proves that those who take hard exercise in the outside air for some hours a day escape these ill effects. The health of sailors and country laborers shows us that sleeping in hot, confined and ill-ventilated quarters is of no consequence if the working day is spent in the open air. It is persistent exposure to the uniformity of warm, windless air which is the cause of the mischief. The conditions of great cities tend to confine the worker in the office all day, and to the heated atmosphere of the club, cinema show, or music-hall in the evening. The height of the houses prevents the town dweller from being blown upon by every wind of heaven, and, missing the wonderful exhilaration of the cool, moving, open air, he repels the dull uniformity of his existence by the moving pictures of the showman and by tobacco.

We have now dealt with the general principles which ought to control the practice of the heating and ventilating engineer. The old English methods of open fire and open window have very much to recommend them. By the open fire air is kept moving and cool air is brought in; the heating is by radiation, and uniformity of the conditions of temperature in the room is prevented. On the other hand, the impulsion of hot air into a room is the most objectionable of all the systems employed. A cool air and radiant heat are the ideal; the hot-air system gives us neither. In cold weather the heated air becomes excessively dry. The vigor and health of children in America have been seriously undermined by the impulsion of hot "desert air" into the schools.

We are now in a position to examine the uses of ozone in ventilation. Ozone is represented by O_3, and differs from the oxygen molecule, O_2, by the addition of a third atom of oxygen, which is loosely bound and has powerful oxidizing properties. It corrodes cork, rubber, and other organic substances, and oxidizes iron, copper, and even silver when moist, and dry mercury and iodine. Galvanized iron tubes or glass can be used for the conductance of ozonized air. Traces of ozone are found in the atmosphere after thunderstorms, produced by the effect of the electric discharge on atmospheric oxygen. It is said that traces of ozone exist in sea and mountain air. Ozone is generated by the silent discharge of high-tension currents from one plate of metal to another across a sheet of insulating material. In the Ozonair apparatus the metal plates are sheets of fine gauze separated by micanite. The discharge takes place from the multitude of points on the gauze, and this equalizes the tension at which the discharge takes place, prevents sparking and the formation of oxides of nitrogen. These oxides contaminate the ozone which is formed when ordinary smooth plates are employed, for the discharge then takes place at a few rough points at a far higher tension and with sparking. It is said to be the sparking discharge in air which causes the oxides to form. Each complete element of the Ozonair apparatus consists of a thin sheet of micanite, covered on each side by a square of gauze. The air can be made to pass by a series of baffle plates over a series of these elements. There are over 230,000 round projections to the square foot of the gauze, from which discharge takes place. The gauze is made of an aluminium alloy of forty meshes to the inch.

The Ozonair Company have placed their apparatus at our use, and we must thank Mr. Edward L. Joseph for his courtesy and assistance in the carrying out of our inquiry. The concentration of ozone can easily be determined by aspirating a 10-liter sample of the air through an acidulated 1 per cent solution of potassium iodide. A little fresh starch solution is added to this. The ozone turns it blue. Titration is carried out with a standard solution of hyposulphite of soda.

On exposing mammals to different concentrations of ozone in our chamber, we have found they may be killed by prolonged breathing of concentrations of about twenty parts per million. The cause of death is an acute irritative inflammation of the respiratory tract. After death congestion of the lungs is found. The ozone in such concentrations causes the eyes to water and makes one cough. It is so irritative and unpleasant that no one would think of continuing to breathe it. Thus a man cannot be poisoned unawares by a dangerous concentration of ozone. He will certainly remove himself from its presence. No harm results from breathing such concentrations for a short period. A slight irritation of the respiratory tract and some sneezing and coughing, and perhaps headache, are the only penalties. The danger signals are clearly set by ozone, and anyone must naturally obey them. When ozone is employed in ventilation it is arranged in such a concentration as to produce none of these symptoms of irritation.

Oxygen in high concentrations (at two or three atmospheres of pressure) is also a poison, and produces not only acute congestion of the lungs, but convulsions. Unlike ozone, oxygen produces no preliminary irritative effect. The breathing of ozone in suitable weak concentrations is no less safe than the breathing of proper concentrations of oxygen. Certain insects are comparatively immune to the effects of high concentration of ozone. For example, we have found that fleas stand exposure to about one hundred parts per million for five hours. This is very unfortunate. Had these parasitic insects only proved highly susceptible we should have found in ozone a clean and ready method of attack.

Ozone can be used in high concentrations for sterilizing water; and herein is to be found one of its most valuable uses. The water is not only sterilized but oxygenated, and ozone can be used, therefore, with great advantage to keep the water of aquaria in good condition. Ozone has been successfully applied as the means of purifying the water-supply of several towns, both abroad and in this country. Where the water-supply is contaminated and the source of electric power is cheap, no better or simpler method can be employed. Ozone is a most powerful deodorizer. It takes away all disagreeable smells. Whether it destroys them or prevents the nose smelling them, is of little importance. The psychical effect is the same—the disgust due to the evil smell disappears. Ozone itself has a peculiar smell. It reminds one of the fumes of nitric acid, and whether the smell is that of ozone or minute traces of oxides of nitrogen, it is difficult to say. The nose may detect what the analytical methods of the chemist fail to show. By the smell we can detect concentrations of far less than one part in a million, and the smell is the safest and easiest guide to a suitable concentration. Ozone should be present in the air for continuous breathing in concentrations not greater than that scarcely perceptible to the smell. Concentrations of even one part in the million are too irritative, and quickly depress the metabolism and lower the temperature of rats, and are unpleasant to man. Very weak concentrations, barely perceptible to the smell, have no

ill effects, but destroy the effect of unpleasant smells and give a certain tang or quality to stuffy air which relieves its monotony and uniformity.

It is in this respect that ozone has its use. There exist in modern conditions of life so many trade shops, tube railways, cold meat stores, etc., where the employees are exposed to a persistent, uniform and depressing smell. The air in many buildings is made to smell by the heating appliance used. The addition of ozone takes away the smell and relieves the monotony of such air, and, as the Ozonair apparatus can, by the turning of a switch, be put in or out of use, the uniformity of the atmospheric conditions can thus be frequently changed. The ozone, no doubt, exerts its effect both on the cutaneous and respiratory nerves.

We have not been able to obtain any evidence that ozone in weak concentrations influences the respiratory metabolism of the resting man. We have studied the effect of ozone both on animals and on ourselves, estimating the amount of oxygen used up and carbonic acid produced during successive periods of time when air or ozonized air was breathed.

The rate of oxidation of the human body is set by the nervous system, which controls the activity of the body. Breathing pure oxygen in place of air has no effect on the metabolism of the man at rest. It will increase the metabolism of a man doing hard work, but only in the case of his working so hard that he suffers from a shortage of oxygen when breathing air. The body, unlike a fire, cannot be fanned up to burn faster. The living substance works at its own rate independent within wide limits of the changing conditions of the outside world. We should not expect, therefore, that ozone would stimulate the metabolism of the resting man. By altering the unpleasant uniformity of a close atmosphere it may help an employee to work more briskly. In high concentrations, ozone, just as high concentrations of oxygen, depresses the metabolism because it is toxic to the cells of the respiratory tract. The ozone which is breathed into the lungs is caught by the wet mucous membranes and none of it is exhaled. It is, no doubt, used up there in an oxidative process of the tissues. It is excess of such oxidative process which damages the cells lining the respiratory tract, when either too great a concentration of ozone (or oxygen) is breathed. There is no evidence that ozone reaches the blood, or that it has any other influence on the body. The effect which ozone in weak concentration has on the olfactory nerves, and those of the skin and respiratory tract, is the justification for its use in ventilation.

The Steam Locomotive

"THE steam locomotive continues to be the most fascinating of all the varied studies presented by engineering," says *The London Times*. "Now and again its pre-eminence may for a moment be threatened either by the brilliant performance of a rival means of propulsion or by the predictions of a theorist, but notwithstanding all that is said and done and written, it continues to reign supreme in its own sphere of usefulness. In seeking for a reason for its persistence, it is realized that the locomotive has a remarkable power of adapting itself to the requirements of the designer, and that it has potentialities that constitute a wealth of reserve force. Within recent years it has been called upon to increase its power, alike for passenger and goods service, and this demand has been met partly by the introduction of higher boiler pressures, and partly by increase of the dimensions of cylinders. Loads, speeds, and lengths of run have become more exacting, and the costs departments have simultaneously directed their efforts toward economies. To meet these requirements, the mechanical engineers of railway companies have been led to investigate the merits of such devices as depend upon the use of oil fuel, compounding, and the adoption of superheating of steam, and it is to be observed that the progressive movement is now in evidence among even the most conservative users and designers. In the matter of superheating, Great Britain is generally regarded as being behind the Continent, and in any case it must be acknowledged that German and Belgian engineers have done praiseworthy work in developing the superheater into a satisfactory appliance for locomotives. At the same time it is fair to state that in this country (England) a considerable amount of steady experimental work has been in progress for some time, and that the great accession of superheaters to British locomotives is the result of careful scrutiny of a very complex question of ways and means. When the proposal to use superheaters for this purpose was first put into practical shape there were great difficulties to be overcome, and it was not desirable to adopt such devices in their original forms. Their use was, in fact, attended by a certain degree of risk, and their economy in working was problematical. To-day the designer is able to record a complete victory, with consequent increase in power, lower cylinder pressures, and greater flexibility to meet the heavy demands that fall upon the most willing of all propelling agents, with the result that the steam locomotive has been given yet another lease of life."

Trade Notes and Formulæ

To Clean Panama Hats.—Concerning the cleaning of Panama hats, we cull the following information from Phar. Ztg., No. 63, 1910. Sodium perborate has proved an excellent agent for the bleaching of Panama hats, a solution in the following proportions being used: Sodium perborate 30 parts, lukewarm water 4,500 parts. Proceed as follows: Wash the hats with soap and warm water with the aid of a brush, to remove the dirt adhering mechanically. After a thorough washing off with water, they are to be immersed in the above-described bleaching bath and left in it for 24 hours, care being taken that the hat fabric is continuously covered by the fluid; any part of the hat that projects beyond the fluid will be stained brown, and the color cannot be removed. It is advisable, however, to stir the bath now and again. Finally, the bleaching bath must be heated to 50 to 55 deg. Cent. (122 to 131 deg. Fahr.). Then transfer the hats to a solution of 30 parts of oxalic acid in 4,500 parts of water, and allow them to remain in it one minute. After thorough rinsing in clear water, it is best to dry the hats in the sun. An enameled vessel is to be preferred for the bleaching bath, but a wooden tub or an earthenware vessel may also be used.

Silver Gray for Straw Plait.—Boil white or bleached straw hats for two hours in a solution of 2,000 parts of pure alum, free from iron, and 100 parts of tartaric acid, then add the necessary proportion of ammonia cochineal and indigo carmine, with a little sulphuric acid.

Stucco Marble for Walls, Columns, etc.—Apply to the rough fresh lime finish, a mortar composed of white or colored wall plaster, smooth it off, and when perfectly dry, coat it with a mixture of 7 parts wax, 2 parts stearine, and 20 parts oil of turpentine, applied hot.

Stucco for Ornaments.—4 parts plaster, 3 parts white lime, 3 parts fine white sand mixed with glue water. If the mass is to be colored, the colors (earth colors and metallic colors) should be mixed dry with the plaster in a tumbling barrel.

Stucco Lustro (in the Vienna houses of parliament).—1 part lime, 2 parts of marble dust, applied with a rubbing board, rubbed down with wooden sticks and smoothed with a polishing trowel. For polishing take 2,000 parts of water, 90 to 110 parts of wax, 40 to 46 parts of soap, and 20 to 25 parts of potash; dip in the mixture a woolen rag and rub with it.

Bronze Imitations with Plaster or Wooden Models.—Plaster or wooden models, when they have fulfilled their purpose, are, as a rule, laid aside and entirely ignored. What can be done with them, anyway? A shaped wooden or plaster model is no presentable article, especially in the opinion of the lay public. It is painted with shellac, soiled with molding sand, in a word it has no color. How much more beautiful and sightly is such a figure when properly and skilfully treated with color. The figure undoubtedly cost much, in work and outlay, and on general principles we would preserve it. And for this reason it may be readily understood, says the *Deutsche Goldschmiede Zeitung*, why we should seek to preserve many pieces of this kind in a new dress, make it presentable, so that it may be evidence of the ability and industry of the maker, of the productions of the concern, and last, but not least, that we ourselves may find pleasure in it.

An elegant and most suitable method of coloring such figures, is to convert them into imitations of bronze. The plaster model we have before us is worth the little trouble and, therefore, we may color it, in dark bronze or iron-bronze, according to the following method. The model having been freed from dust is coated with ordinary varnish, applied, two or three times with a brush. As soon as the varnish has dried in, the model is coated with a copper or gold bronze, soluble in oil. After this color is dry, mix powdered graphite with some oil and varnish and apply the mixture, to cover evenly. Careful work will give the piece a dull shining appearance. We then take a soft cloth and rub, freeing the prominent places, or the noticeably projecting parts of the piece from the graphite coating, until the bronze coating is again visible. Care must be taken not to rub too much, or the effect of the object as a whole will suffer and it will lack repose.

Another process is to mix brown shellac, dissolved in alcohol, with umber or Cassel brown and coat the figure with this mixture, applied as thinly as possible, until, after drying, the object assumes a uniform dull appearance. The plaster model is then placed near the stove so that it is warmed through and through. This is necessary for the last process. Fluid, heated wax is thinned with oil of turpentine, Cassel brown or umber added and the warm model painted with the mixture. After cooling, the strongly prominent or raised parts are polished, by rubbing with a soft brush, and some zinc-green is applied or dusted into the deep places.

In both the two last described processes, the dusting or painting of the deep spots, with a little zinc-green, or verdigris, heightens the effect. Wood models may be treated in the same manner as plaster.

Science Notes

Athletes and Long Life.—In answer to the query "Do athletes die young?" Dr. William G. Anderson, director of the Yale University gymnasium, has given the results of a study of the college records for fifty years. A comparison of the mortality of specialized athletes with the general graduate who has not distinguished himself in athletics shows in favor of the athlete. Of 10,922 students in academic and Sheffield classes from 1855 to 1905 inclusive, 1,406 have died, and 9,516 are still living. This shows the percentage of deaths to be 12.9 per cent. Of the 207 athletes from 1855 to 1905, only 58 are dead, a percentage of 7.2, or a little over half that of the general graduates. Dr. Anderson concludes that the Yale athletes do not die young, nor is heart disease a leading cause of death in them. Lung trouble is the cause of the greatest number of deaths, but the percentage of men dying from these causes is not greater than the expected death rate among non-athletes from similar causes. However, although the athlete is not short-lived, the statement is not warranted that he owes his longevity to athletics.—*Medical Record*.

Glass Highly Permeable to X-Rays.—As is well known X-rays have their origin in Crookes tubes at the point where the cathode rays impinge upon an obstacle, such as the anti-cathode. They differ from ordinary light, probably in that they are constituted of short pulses rather than continued waves. Now it so happens that the tubes which are used to produce X-rays, themselves absorb a considerable portion of these; in fact, from 52 to 70 per cent, supposing the glass to be 7 millimeters thick. According to the ideas of J. J. Thomson and his school, the degree of absorption depends mainly on the atomic weights of the elements entering into the composition of the glass. The idea therefore presents itself to use glass of a suitable composition, so as to reduce the amount of absorption. This has been done by the use of a glass containing boron, lithium and beryllium, in place of silicon, sodium and calcium. From the following table it will be seen how the atomic weights of these substances are related to one another:

Silicon,	28	Boron,	11
Sodium,	23	Lithium,	7
Calcium,	40	Beryllium,	9

The new glass which is obtained is found to be five times more permeable than ordinary glass to X-rays of medium hardness. Unfortunately, this glass is rather rapidly corroded by the air. This effect can be in some measure avoided by coating it with a thin film of gum-lac varnish.—*Cosmos*.

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